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CONTRACTS FOR THE BUILDINGS AND GROUNDS of the Louisiana Purchase Exposition, at St. Louis, Mo., will be let about Dec. 1, 1901. The contracts to be let will involve an expenditure of about $11,000,000, of which $7,000,000 will be for buildings and $4,000,000 for the grounds. The first contracts to be let will be for the four main buildings, which will cost about $4,000,000. The site to be occupied is the unfinished part of Forest Park, and this site has been surveyed and the lines of the buildings and avenues staked out. The designs for the separate buildings assigned to the individual members of the Commission of Architects, will be submitted in scale drawings by the middle of October, and the working drawings of the main buildings to be let first will be ready by Nov. 1. The lettings will be advertised for about three weeks in the leading technical journals throughout the world. There will be no geographical restriction on bidders. The main stipulation will be that the buildings be ready for occupancy at a date sufficiently far ahead of April 30, 1903, the date fixed for the opening of the exposition, to allow exhibitors time to prepare their displays for the opening. To secure the completion of the buildings by this time a sufficient bond will be required of the successful bidders. All work will be under the direction of Mr. Isaac S. Taylor, Chairman of the Commission of Architects, St. Louis, Mo.

THE CONTRACT FOR THE TAIL-RACE TUNNEL of the Canadian Niagara Power Co., on the Canadian side of the Falls, has been awarded to Anthony C. Douglass. The expenditure on this contract will, it is stated, be over half a million dollars. The length of the tunnel will be about 2,300 ft. It will have a horseshoe-shaped cross-section, the same as the tunnel on the American side, and it will be lined with brick throughout, the nature of the rock through which it will pass being quite identical with that through which the tunnel of the Niagara Falls Power Co. was built and which was lined with four courses of vitrified brick. The section of the new tunnel, however, will be somewhat larger than the present power tunnel, which approximately is 21 ft. high and 18 ft. wide. The new tunnel will extend from a point at the head of Cedar Island to the gorge, breaking into the lower river a few hundred feet below the Horseshoe Falls on the Canadian side. Work will be carried on night and day. A shaft 185 ft. deep and 10 × 16 ft. has been sunk at the head of Cedar Island preparatory to the tunnel construction. It is provided in the contract that the tunnel shall be completed by Jan. 1, 1903. The wheel-pit contract has not yet been awarded.

ELECTRIC POWER ON THE GREAT NORTHERN RY. is said to be contemplated by President Hill. It is stated that the work of thus equipping a 65-mile portion of the Cascade Division will be started in the near future. Investigations conducted during the last three years by Mr. J. N. Hill point to great economy in utilizing electricity generated by water power. At present coal is very expensive on this mountain division, rising as it does continuously for about 30 miles, and about 250 tons of coal are consumed here daily, costing $2.75 or more per ton.

ELECTRIC POWER FOR BELGIAN COAL MINES has been adopted for one of the most important groups in the Charleroi District, says U. S. Consul Geo. W. Roosevelt, of Brussels. A central station is being erected to supply power to three mines situated several kilometers apart. The pumps are placed at the bottom of shafts 1,640 ft. deep, and the electric current is transmitted from the generators over three small wires mounted on poles and conducted into the shafts by a cable sheathed in steel. These electric pumps occupy little space in the gallery and work from 150 to 200 strokes per minute. This electric power will also probably be used later for hoisting, washing and sorting the coal, operating the small mine cars and for lighting purposes. The plant being put in place comprises four electric pumps of 200 HP. each, and two groups of generators giving 1,200 HP. in all.

THE NEW LACKAWANNA STEEL PLANT, at Buffalo, N. Y., was commenced less than two years ago, and progress upon it is reported as follows by a correspondent of "The Iron Trade Review." The plant is located at Stony Point, on Lake Erie, and its total cost is estimated at $25,000,000 by its builders, the Lackawanna Iron & Steel Co. Ten substantial buildings are completed and several others are commenced; several shops are in operation, making patterns and storing supplies; one large blast furnace is nearly completed and another has been started; a considerable quantity of machinery is already installed and more is coming almost daily; the dredging of a ship canal, to connect it with the Lake, has been started, and a large tunnel underneath the canal is being dug. The completed buildings include office structures; a machine shop, 300 × 80 ft. and 50 ft. high; a boiler shop, 300 × 80 ft. and 30 ft. high; a foundry, 500 × 80 ft. and 50 ft. high; a pattern shop, 50 × 100 ft., two stories high, with a pattern storehouse of the same size and four stories high adjoining; a power house, 30 × 50 ft.; a carpenter shop, 50 × 100 ft., two stories high; a supply shop, 50 × 100 ft. Over 800 men are employed in erection. The canal to be built by Hingston & Wood, of Buffalo, will be 200 ft. wide and about a mile long; it will cost $700,000 for the digging contract alone. Estimates place the completion of the plant some time in 1904.

THE MOST SERIOUS RAILWAY ACCIDENT of the week was a collision on Sept. 30 of two freight trains on the New York, New Haven & Hartford R. R. near Long Hill Station, Connecticut, in which three persons were killed and three others badly injured. The collision was caused by the engineer of one of the trains forgetting orders.

THE EXPLOSION OF AN OIL TANK on Sept. 26 at the works of the Essex & Hudson Gas Co., of Newark, N. J., killed six men. The steel tank was 20 ft. deep and was undergoing its periodical cleaning. Two men entered through a manhole, and it is supposed that one of the chisels, in striking the steel, emitted a spark, which caused the explosion. The other men killed were on top of the tank. The tank was split in twain.

THE CENTRAL LONDON RY., better known perhaps as the "tuppenny tube," was obliged to suspend its entire train service on Monday afternoon, Sept. 2, for about three-quarters of an hour on account of trouble in the power station. From an account in the London "Electrician," it appears that the trouble was caused by a change in coal. The boilers are fitted with automatic stokers, and the new coal formed clinkers so rapidly that the firemen, who were unaccustomed to the new fuel, were unable to keep up the steam pressure. It is stated that the change in coal was made on account of complaints against the company for discharging black smoke from the power house chimneys.

A LEAF-ARRESTER FOR WATER SUPPLY was described by the Earl of Rosse at the last meeting of the British Association. The water supply to a turbine of 15 HP., with 8-ft. fall, was much reduced in volume at times by leaves, etc., choking up the screen in the supply channel, though this had an area of 100 sq. ft. A cylinder of wire gauze, 4 ft. in diameter and 4½ ft. high, was set in an opening in a vertical diaphragm extending across the supply channel, and revolved about twice in a minute on a vertical axis. The current flows through the gauze cylinder in a horizontal direction; and the leaves attach themselves under pressure from the stream. These leaves are carried round until they reach the diaphragm, which is double on the lower side, and through an intervening space of 10 ins. flows a stream from the tail-race. On the lower face of the cylinder the current through the gauze is relatively reversed; and the leaves are detached and carried away in the current from the tail-race.

CONVERTIBLE BALLAST AND COAL CARS are being introduced by the Rodger Ballast Car Co., of Chicago, and are formed by a modification of the standard Rodger ballast car, which has been described and illustrated in our columns. The ballast car forms one long hopper, the hopper bottom extending the full length between the trucks. The new cars have vertical sides, as in an ordinary gondola car, and a double row of hinged doors closes the hopper opening, which is about three-fourths the width of the car. With these doors closed, the car is an ordinary coal car. When they are raised and thrown back against the sides they form a sloping surface above the hopper, and the car is thus converted into a dump car for ballasting or filling. A car weighing 34,000 lbs. has a capacity of 37 cu. yds. of ballast or 40 tons of coal.

THE STONE ARCH BRIDGE built by the Pennsylvania R. R. Co. over the Susquehanna River at Rockville, Dauphin county, Pa., is approaching completion. This structure—which replaces an iron bridge—is 3,820 ft. long, 50 ft. wide, and includes 48 arches of 70-ft. span. This bridge was illustrated and fully described in our issue of May 10, 1900.

THE MEXICAN NATIONAL RAILWAY, according to a news item from the City of Mexico, is proposing to change its track from narrow to standard gage within the year, between Laredo and the City of Mexico.

THE COMPLETION OF THE TRANS-SIBERIAN Ry. along the tortuous course of the Amur River has been decided upon by the Russian railway authorities, says the U. S. Commercial Agent, Mr. R. T. Greener, at Vladivostock. This would be in addition to the line across Manchuria, now under construction, and follows the original surveys made before the latter line was in contemplation. Mr. Greener says that the Mukden line, destroyed by the Boxers, is being rebuilt.

TESTS ON THE TIMBERS OF THE PHILIPPINE Islands are to be conducted by the U. S. Bureau of Forestry, it being the intention to establish a testing laboratory at Manila as soon as possible. It is especially desired to test the various processes for the preservation of timber against decay and the attacks of insects, and all persons having such processes are asked to communicate with Mr. S. T. Keely, Superintendent of Tests, Bureau of Forestry, Washington, D. C., with the view of having their processes tested on Philippine timbers.

THE ASPHALT FIELDS of St. Jo, Montague county, Tex., have been reported upon by Mr. H. C. Alford, an asphalt and petroleum expert of St. Louis, in the interest of the St. Louis Oil & Asphalt Co. He believes that the St. Jo asphalt district is a continuation of the asphalt districts of the Indian Territory. The samples of asphalt examined contain from 30 to 45% of petroleum; and in the crude material in the outcrop he found from 60 to 75%. He says the indications point to petroleum at a depth of about 1,500 ft., and thought that the oil would have a very slight asphalt base, very little paraffin, and would probably be a fair illuminating oil with a minimum of sulphur.

THE THIRD ANNUAL STATE COMMERCE CONVENTION will be held in the city of Buffalo, beginning Oct. 16. All commercial bodies in the state of New York, including boards of trade, chambers of commerce, manufacturers and merchants associations and exchanges, are invited to attend. The object of the convention is to consider all matters relating to commerce and manufacture within the state. Full particulars as to delegates, transportation, headquarters, etc., can be secured by addressing Mr. Frank S. Gardner, First Secretary, 203 Broadway, New York city.

A BUREAU OF AGRICULTURAL ENGINEERING has been suggested by Mr. F. E. Warren, U. S. Senator from Wyoming, in a letter to the Secretary of Agriculture. The bureau would have charge of both the irrigation and road inquiry investigations now being carried on by the U. S. Department of Agriculture. In addition it would study such questions as the reclamation of swamp lands, the protection of hillside farms from erosion, and the best types of agricultural machinery.

THE CHICAGO & JOLIET ELECTRIC RY. was opened Sept. 25, a party of over 300 guests from the two cities being taken over the line in special cars and entertained at lunch at Joliet. The line is one of the interurban electric railways promoted by the American Railway Co., of Philadelphia, Pa., of which Mr. A. S. Kibbe is the engineer. It extends from the Chicago city limits at Archer Ave. (connecting with the Chicago City Ry. Co.'s system) to the city hall at Joliet, passing through Summit, Lockport, Lemont, etc. It is built partly along the public road and partly on its own right of way. For the greater part of the distance it is laid with T-rails, spliced with six-bolt angle bars, except through the streets of towns. It is operated on the overhead wire system, and each car has four 50-HP. motors. The main power station is at Joliet, operated by current from the water power and electric generating plant in that city. From the main station current is sent at 15,000 volts to two substations, while the voltage on the trolley wire is 600 volts. Mr. F. E. Fisher is General Manager.

SOME SUGGESTIONS AS TO SPECIFICATIONS FOR STEEL RAILS.

By E. F. Kenney.*

The subject of betterment in rail-making having received so much more attention recently, and the possibility of engineers securing an improved practice on the part of the makers encourages the author to put forward some suggestions which have occurred to him from time to time.

COMPOSITION.

The chemical composition of rails is largely a question of locality; what we would like to get is sometimes impossible. There are few engineers who, had they a free hand, would not keep the phosphorus low—very low—but in the Western mills particularly, this is well nigh impossible. As the amount of carbon is decided by the phosphorus, the carbon content too becomes a question of locality. Where the phosphorus can be kept below .06 or .07 of one per cent, the carbon can be raised considerably (.55 to .65 in 100-lb. rails) without danger of brittleness; but with higher phosphorus metal (up to .10) the carbon must be kept lower (.40 to .50). There seems to be little doubt that the low phosphorus-high carbon rails are better, but as long as the acid process is used exclusively, we will have to be satisfied with a maximum limit of .10 phosphorus. This subject has been threshed over pretty thoroughly, and the kinds and proportions of hardeners for rail steel are quite well understood; it is mainly a question of the practicability of obtaining commercially what we think is best. This is for the general run of rails; there are circumstances under which it is found better to have special rails made for special service. A Bessemer steel rail containing 3% nickel, 0.50 carbon and 0.094 phosphorus is giving excellent service on a sharp curve with heavy grade where the tonnage is very heavy and the speed slow. Ordinary rails wear out rapidly at this point, but the nickel steel rails show almost no signs of wear after more than a year's service. These rails cost more than ordinary rails, but from present indications the additional cost will be more than made up in the amount which would be spent in replacing. The only trouble with these nickel steel rails has been their hardness; it is very difficult to cut them, and drilling them with ordinary tool steel is next to impossible. A decrease of five points in carbon would probably make the rails easier to work and less liable to break without detracting much from their wearing qualities.

BLOOMING.

This is a subject on which most specifications are conspicuously silent, and yet it is most important. There is a unanimity of opinion that the minimum should be in proportion to the weight of the finished section.

The character of work in blooming is a large factor. The blooming is the best opportunity to get heavy work on the steel. Light, feathery touches are entirely out of place in blooming; the metal should receive as heavy work as it will stand without cracking. Rails from two mills representing light and heavy blooming respectively, chemically similar and finished at practically the same temperature have been found very unlike, and the advantage is always with the heavier work. The average reduction per pass in the blooming of our different mills varies from 12% to 24%. In the former case it is doubtful if there is much effect produced on the interior metal, and

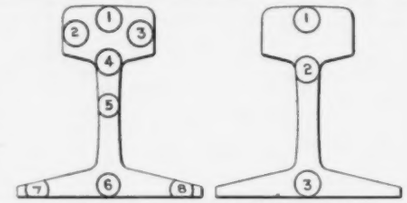


Fig. 1. Rail Sections, Showing Method of Sampling to Detect Segregation.

at all events the product is much inferior to that of the heavier mills; at least that has been the experience of the author.

Heavy work in blooming, too, admits of starting the ingot at a lower and therefore better temperature. The rapid contraction of section in heavy rolling is almost sufficient to replenish the heat lost by radiation, and the temperature of the finished bloom is not very different from that at which it entered the initial pass.

SEGREGATION.

This is generally looked on as an evil impossible to prevent, and in all probability it is; but is there sufficient effort made to keep it down to a minimum? Some Bessemer men think it is largely a function of the temperature at which the steel is poured, but one prominent man has advanced the theory of improper heat treatment of the ingots. He thinks the elements pass from one part of the ingot to another under the influence of excessive heat much in the way that carbon does in the cementation process. These opinions are stated only to support the view that some of the segregation might not be unavoidable, and that if excessive segregation were penalized there would be more effort made to prevent it.

The average percentage of croppings from rail steel is about 10%, which includes both ends, making it roughly about 5% from each end, in fact, small sample cast direct from the ladle. This sample is so small that it cools too rapidly to admit of any material segregation, and we judge the value of the entire heat from the data obtained from the sample. Now, the strength of a rail, like the strength of anything else, is the strength of its weakest part, and the value of the weakest part determines the value of the rail. Of what use is it to have the average phosphorus content of a whole rail at 0.08 or 0.09 and yet have one part of that rail with phosphorus running up to 0.20, combined with excess of carbon? When it breaks, it will break where the steel is poorest, and that is the portion of the rail in which we have the greatest interest.

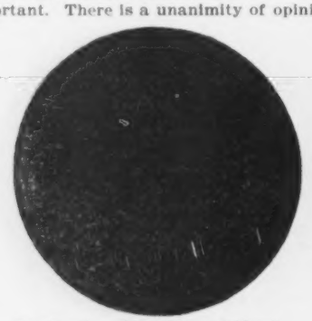
The segregation mentioned above actually occurred in a broken rail analyzed recently. The average of the heat was C .45 — P .09 — S .076 — Mn .93, and the analysis at the point of fracture was C .61 — P .20 — S .22 — Mn 1.03. This is the worst case encountered in a recently rolled rail, but it is by no means an isolated one; similar cases, different only in a small degree, are but too common.

In looking into the matter of segregation in rails, we have been taking from each rolling of rails a number of sections 1½ ins. thick. From each of these we took drillings, at first as shown in Fig. 1, but found that the results obtained from hole No. 1 represented that of all three upper holes; hole No. 4, the two holes in the web, and hole No. 6, the three in the base of the rail, making it necessary to analyze only three sets of drillings from each section. The segregation shown at the junction of the head and web—the part of the rail which occupied the center of the ingot—is often very marked. If such excessive segregation were penalized, we would have less of it.

FINISHING.

Lately there has been considerable attention paid to the temperature at which the work is done in rolling, and micro-photographs seem to indicate a much finer structure in the steel that has been rolled colder than has been the custom heretofore. Superiority is indicated also in records of service of rail so made. Although no process has been operated on a commercial scale long enough to thoroughly demonstrate this fact, yet the evidence all points that way. There is one instance where the usual life of the outside rail on a sharp curve was 11 months; colder rolled rails have been in this curve for 14 months, and they are yet good for some time to come. At the end of the 11 months the wear on the cold-finished rails was 42% less than on ordinary rails which had been in the same location the same length of time. This was in spite of the fact that the tonnage passing over the track during the use of the cold-rolled rails was greater than for the ordinary ones. This is, of course, not conclusive, but rather indicative.

The method of obtaining the best results in colder rolling is an open question. That the rather small percentage of reduction (5 to 9%) in the finishing pass does sufficient work to thoroughly rearrange the structure of the steel has been questioned, and some rail-makers contend that the colder rolling to be of any value should be done not only in finishing, but in the roughing and intermediate rolls where the work done is much



Section from Top Edge of Head.

Section from Center of Head.

FIG. 2. SECTIONS FROM COOLER RAIL; SHRINKAGE ALLOWANCE, 5½ INS. FOR 30 FT.

Analysis: C, 0.436; P, 0.09; Mn, 0.65; Si, 0.09; S, 0.056; Cu, 0.056.

Section from Top Edge of Head.

Section from Center of Head.

FIG. 3. SECTIONS FROM HOTTER RAIL; SHRINKAGE ALLOWANCE, 6 5-16 INS. FOR 30 FT.

Analysis: C, 0.521; P, 0.100; Mn, 1.05; Si, 0.108; S, 0.047; Cu, 0.064

FIGS. 2 AND 3. MICROPHOTOGRAPHS FROM RAILS FINISHED AT DIFFERENT TEMPERATURES.

difference of wear in favor of light section rails over heavier sections is because of the difference in the amount of work done in rolling. For years the weight of rail sections has been steadily increasing from 56 and 60 lbs. to 100 lbs. per yd., but there has not been a proportionate increase in the size of the ingot from which the rails have been rolled. Some of the mills are using the same size ingot to-day as when 70 lbs. was the heaviest section rolled. There should be a minimum size of ingot specified for each section of rail and the only enough to get steel physically perfect. There is no attempt made to crop off the zone of greatest segregation, such as is done in making axle steel, though from some recent experience with badly segregated rails it might be an economical course to insist on a similar practice in rails, and pay the additional cost. In any event it would be well to have analyses made of drillings from the web of the rail which formed the upper part of the ingot to guard against excessive segregation.

We speak of rail steel as containing less than 0.10 phosphorus, and the amount of such phosphorus content is determined by analysis of a

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greater. On the other hand, Mr. Morrison told the writer that in experimenting, before the adoption of the Kennedy-Morrison process at the Edgar Thomson Works, he found that holding at the finishing rolls gave a better structure than holding the rails at any of the roughing or intermediate rolls.

Whether or not the holding at the finishing pass will give as good results as rolling colder all the way through the operation, it is quite certain that colder finishing, even when done only in the one pass, is giving better structure than the old practice.

Appended are micro-photographs of sections taken from two 85-lb. rails, the difference in whose finishing temperatures is shown by the shrinkage allowance for each.

One photograph is taken at the center of the head; the other very close to the top edge of the head of the rail. The fine structure in the colder-finished rail is not confined to the edge; of course the edge is finer than the center, but the effect of lower finishing temperature is shown by comparing the center of this rail with the other. These are not exceptional cases, but only a fair average of what has been obtained in investigation.

A colder-finishing temperature is certainly coming, and though it has its disadvantages to the rail-maker, the results already shown are sufficient to warrant a specification requiring it. The use of a color clause in describing the finishing temperature, though, is misleading; what appears to be a dull red heat in a dark mill is a far different temperature from what appears a dull red heat in a well-lighted mill. A dull day or a bright day will make a great difference. The most practical way to fix the finishing temperature is by the length allowed for shrinkage. If the saws are placed near the finishing rolls, as they are in most of our rail mills, the distance between the saws will serve as a very close measure of the finishing temperature.

STRAIGHTENING.

There are more rails ruined in the straightening presses than anywhere else; for instance, a little carelessness at the curving wheels, and the rails will come from the hot beds with an exaggerated camber; the first operation of the straightener is to hit the rail with the gag every 18 ins. or 2 ft. for its entire length. When we take into consideration the fact that the steel is being strained beyond its elastic limit at each blow, the danger of this sort of treatment is very striking. If it were a necessary evil, it might be looked upon with more equanimity, but when it is known that it is the result of carelessness in the mill, something should be done to stop it. There is no reason why an extreme camber should not be specified, and all rails arriving at straightening presses with a greater camber should be rejected. There are some mills where a survey of the cooling beds will show practically uniform curvature in the rails; the lines are nearly parallel for rails in the same portion of the cooling beds, while at other mills the rails will be found in all shapes, sometimes every alternative rail with camber reversed. The author believes that uniform working of the curving wheels and uniform finishing temperature will go far toward eliminating the greater part of the gagging, and would recommend a specification demanding it.

Attention should be paid to keeping the seats on which the rails rests while being straightened a true plane. It only requires a slight hollowness to cause the rail to be supported only at the thin edges of the base, then when the gag strikes the head, the base of the rail is subjected to a bending strain until the center of the base is forced down to the bottom of the hollow portion of the seat. This is shown in an exaggerated way in Fig. 4. It is rather severe treatment for steel as hard as 100-lb. rail steel, and in all probability some of the failures in rails get their start in this way.

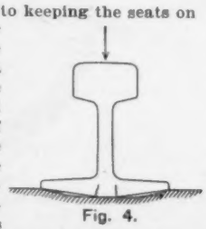

Fig. 4.

TESTS.

The specifying of a drop test seems to be almost universally regarded as essential; and yet unless the portion of the ingot from which the test piece comes is known, the drop test may be quite misleading. We are to judge an entire heat —sometimes five entire heats—by the behavior of one sample which may come from the best part of an inferior heat of steel, and yet because it is the best part of the heat, it may stand the test and cause the acceptance of poor material. On the next test we may reject one or five heats because a test piece taken from the top end of an ingot has failed, although the heat as a whole may be better than the heat previously accepted. The test pieces should be taken from some designated location, preferably from what was the top of the ingot, for then we are reasonably sure that all the rails represented by that test piece are at least equal to, and probably better than, the test piece.

There should be some approximate temperature specified at which tests are to be made, particularly if there is a maximum deflection specified under the drop test. Last winter we were making tests on some 85-lb. rails, and found the butts stacked up at the testing machine where the temperature was about 20° F. Some hot crop ends were laid on the rail butts to take the chill off, but one butt was put aside without heating. Under a blow of 40,000 ft. lbs., the warmed rails gave an average deflection of 2⅞ ins. between supports 3 ft. apart, and none broke, but the cold rail broke with almost no deflection. This was an extreme case, but it shows in an exaggerated way the effect of temperature.

The shape of the striking surface of the tup is also of considerable importance in specifying a maximum deflection. It is generally cylindrical, but the radius of the cylinder varies from 5 ins. to 14 ins., and the results obtained vary with the radius; the smaller radius, of course, causing the greater deflection, so that some qualification of the shape of the tup should be made to insure uniformity of the tests.

THE SUBAQUEOUS TUNNEL SIPHONS OF THE MASSACHUSETTS PIPE LINE GAS CO., BOSTON, MASS.

By W. W. Cummings.†

GENERAL CONDITIONS.—At the first of the year 1899, in the distribution of its gas, the Massachusetts Pipe Line Gas Co. found itself confronted by the problem of three river crossings: The Mystic River at Malden Bridge, Charlestown near Everett; the Charles River, at the new bridge between Charlestown and Boston proper; and the Charles again at the River St. bridge, between Cambridge and Brighton. The size of the pipe at the Malden bridge was to be 54 ins., that at the Charlestown bridge 42 ins., and that at River St. 48 ins. It was necessary to avoid "pockets" in the pipe, which would tend to obstruct the passage of the gas by the collection of water of condensation, and to provide for the removal of this drippage. The pressure head in the tunnels, when passing gas, was liable to vary from 3 to 12 ins. water column, i. e., the problem was to keep the water out rather than the gas in.

The requirements of the State Board of Harbor and Land Commissioners were as follows: For the Malden bridge the top of siphon must not be less than 23 ft. below mean low water, and the clear width of draw opening must be at least 43 ft.; for the Charlestown bridge the top of siphon must not be less than 28 ft. below mean low water, and the clear width of draw opening at least 50 ft.; for the River St. bridge the top of siphon must not be less than 10 ft. below mean low water, and the clear width of draw opening not less than 36 ft. This gave a minimum cover of 7 ft. at the Malden bridge, and none whatever at the Charlestown bridge, or at the River St. bridge, so far as the Harbor Commissioners were concerned. As a matter of fact, the legs of the siphon were placed farther apart than these requirements, in order to provide room for fenders and for working of the draw, while the least safe cover was about 8 ft. of earth. It was also necessary to avoid obstructing the channel during construction.

At Malden bridge a siphon in place would cost $14,000, and the approach on piles (800 ft. in length) $15,000, fenders $20,000, a total of $49,000 from bank to bank. Bids were received from Charles Haskin for constructing a tunnel and laying the pipe for $33 per lin. ft., the material to be furnished by the pipe line company. This made a total of about $50,000 from bank to bank, as against $49,000 for the ordinary siphon. This difference in cost was more than balanced by the advantages afforded by the tunnel, which would be practically indestructible, independent of the changes in highway traffic and navigation, and free from liability to accident and need of repairs.

*Abstract of a paper read before the Boston Society of Civil Engineers on April 17, 1901, and printed in the "Journal of the Association of Engineering Societies," for June, 1901.

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At the Charlestown bridge two siphons would have been necessary, if constructed in the ordinary way, at a cost of about $24,000 and $10,000 for the extra fenders, while the bids for a tunnel under the two draw-spans was $51 per lin. ft. for driving the tunnel and $11 per ft. for laying the pipe and concreting, all material to be furnished by the Massachusetts Pipe Line Co. as before, making a total of $36,000, as against $34,000 for the ordinary siphons. At this time the advantages of a tunnel were so obvious that it was determined to use that construction here also.

About April 1, 1898, the Malden bridge tunnel was started with a time limit for completion set at Aug. 1 the same year, and contracts were made for the completion of the other two a month later, Sept. 1 being the time set for turning gas into the mains. As a matter of fact the Malden and Charlestown tunnels were completed about Dec. 1, 1899.

Three methods were suggested in the design of the tunnels. In all of these the tubular casing by wooden lagging (a method originated by the contractor, Mr. Charles Haskin, and described later) was considered. One plan was to line the lagging with brick masonry laid under compressed air, and to lay the pipe or pipes on blocking, free and open to inspection, repair and possible future additions. Had the fluid to be carried been water instead of gas, the convenience undoubtedly would have outweighed the possible extra cost. As it was, the advisability of avoiding anything that might be converted into a gas pocket prevented such constructions, while the rigidity of the structure was best obtained by making it one solid piece, as by filling the space between the pipe and the lagging. In sinking the shafts it was proposed to use ordinary sheathing until the water should be reached, and from that point to sink a steel tubular casing by means of compressed air.

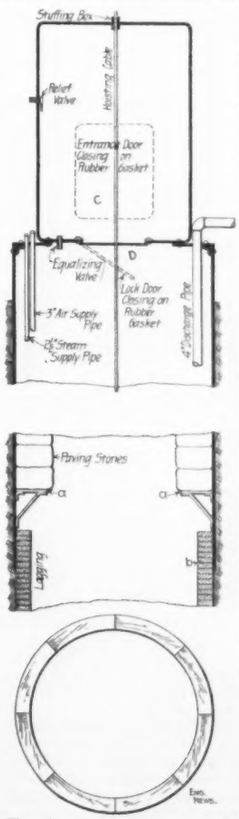

Fig. 1. Steel Caisson and Segmental Lagging Used in Sinking Shaft of Malden Siphon Tunnel, at Boston, Mass.

MALDEN BRIDGE TUNNEL SIPHON.—At the Malden bridge wash borings were made and compared with those of the Metropolitan Sewerage Commission, which had driven a tunnel a few feet to the east. It might be said here that in all cases these borings, although made by a responsible firm, were chiefly remarkable for their unreliability.

The first shaft was sunk on the Everett side of the Malden bridge, as near the abutment as the retaining wall would allow. After going about 6 ft. the steel caisson was erected and sunk in the ordinary way (Fig. 1), paving stones being placed on the shelf at a and the excavation carried on under the cutting edge b. The casing was kept plumb by varying the excavation and also by such guides as might be used at the top. The caisson was extended by removing the air lock and inserting a 10-ft. section, calking the flanged joints when necessary. This shaft was 46 ft. deep, 43 ft. below high water, at which times, of course, the air pressure was about 23 lbs.

The steel casing, was made of ⅜-in. boiler plates riveted to a 3-in. angle iron, which, with the corresponding angle iron of the next section, formed a flanged joint that was made up with red lead and calked where necessary. The inner diameter of the tubing was 7 ft. and the length of a section was generally 10 ft., each section weighing about 4,000 lbs.

The cutting edge was made on the first section by placing a wide flange 2 ft. back from the bottom and staying it with brackets as shown at a. On this shelf the paving stones were placed, to balance the upward pressure of the air and to furnish a downward thrust at the cutting edge. Stones, piles, sunken timbers, etc., were broken up and taken out through the lock. When material sufficiently compact to prevent the escape of the air was reached the sinking of the caisson was stopped, and the lagging was carried down the shelf, as shown in Fig. 1.

This lagging consisted of circular segments 6 ins. wide,

started. The enormous head made 36 lbs. air pressure necessary, and also greatly increased the leakage, as much as 1,000,000 gallons daily being pumped by three Knowles 5-in. pumps.

After going a short way, the roof material changed to sand and continued so to the completion of the tunnel. "Blow-ins" and "breakdowns" were of every-day occurrence, and every incentive was used to keep the men at work.

Negroes were worked in one heading and white men in the other, pitted against each other as to courage and record; extra time was given and shifts shortened, but under the heavy pressure, with the temperature at 105° and the slow laborious methods necessary in the uncertain

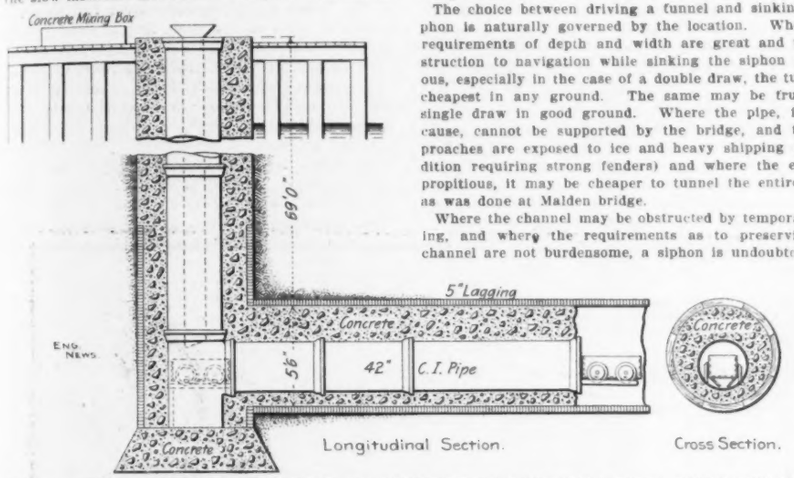

FIG. 5. SECTION SHOWING METHOD OF CONCRETING CAST-IRON PIPE, CHARLESTOWN SIPHON TUNNEL.

heading, progress was very slow, and it was only the indomitable courage of the contractor that carried the work to a successful completion.

The general method of procedure was as shown in Fig. 4. Poling planks were driven ahead, a couple of feet of the sand was excavated, the surface was smeared with clay to hold the air and a bulkhead was thrown across. The clay bottom was then excavated, the lagging brought forward and a new start made in the sand. Progress was from one to three feet a shift in each heading.

The results in alinement were such that it was necessary to make two offsets of 2 ft. each, to keep the transit line in the tunnel. Nevertheless the closing error was less than 0.05-ft.

The lagging was lathed and plastered with cement, and about 6 ins. of concrete was placed in the bottom while the air pressure was still on. The air lock was then removed, and six 12-ft. lengths of 48-in. pipe, with the drip, were lowered in the Cambridge shaft, the lock was replaced, and these were hauled through to the Brighton shaft, where two lengths were supported in the shaft while the drip was set and concreted.

These two pipes were then set and concreted, and a 6-in. drain pipe was laid in the concrete connecting the tunnel with that part of the shaft above the pipe. The five other lengths were laid from the drip in the tunnel, and the 6-in. drain pipe was continued beneath them. Owing to the rapid rise in the tunnel, this had the effect of materially reducing the head, and when six more pipes were laid in the tunnel in the same way, an attempt was made to proceed without the air pressure.

There was too much leakage, however, for the three pumps in the Brighton shaft, and there was no room for more pumps. Moreover the pumps or their connections were continually breaking down and it was decided to lay the pipe under pressure.

The general methods were about the same as those used in the Charlestown tunnel, except the plastering of the lagging, the laying of the 6-in. drain, and the handling of the concrete. The concrete was mixed on top, lowered through the air lock in canvas bags, 12 or 16 at a trip, and wheeled to the point of laying in three or four barrows, four bags filling one barrow. As each man dumped his load, he wheeled his empty barrow into the pipe, to make room for the man behind him. The proportions of the concrete were: 1 cement, 2½ sand, 5 broken stone. In two hours this set sufficiently to permit walking over.

As a rule three 8-hour shifts of 9 men each were employed in driving the tunnel, and progress was about 3 ft. each shift. In laying and concreting the pipe, there were two 11-hour shifts of from 11 to 13 men, averaging one pipe each shift. There were eight batches of concrete to each length of pipe. The men received 23 cts. an hour when working under pressure. As in the other tunnels, all joints on the inside of the pipe were filled flush with cement.

COST AND QUANTITIES.—The cost of the Malden tunnel was $35.34 per lin. ft. for driving the tunnel, $15.50 per lin. ft. for the pipe, and $4.80 per lin. ft. for laying the pipe and grouting, or $55.64 per lin. ft. complete. On the Charlestown tunnel the cost was as follows: Driving and fenders, $87.45 per ft.; pipe, $4.35 per ft.; laying, $9.60 per ft.; total cost, $101.40 per ft. The quantities were as follows: Concrete, 420 cu. yds.; 42-in. pipe, 85 tons; cement, 260 bbls., at $2.35 to $2.75; sand, 200 tons at 70 cts.; stone, 600 tons at $1. At the River St. tunnel the cost was as follows: Driving, $48.84 per ft.; laying, $45.45 per ft.; pipe, $5.36 per ft.; total cost, $99.65 per ft. The quantities were: Concrete, 560 cu. yds.; stone, 1,303 tons at $1.10; sand, 97 loads at $1.00; 48-in. pipe, 169 tons; cement, 879 bbls. at $2.35 to $2.75. Cost of labor on concrete in tunnel about $5 per cu. yd.; cost complete of concrete in tunnel about $9 per cu. yd.

The choice between driving a tunnel and sinking a siphon is naturally governed by the location. Where the requirements of depth and width are great and the obstruction to navigation while sinking the siphon is serious, especially in the case of a double draw, the tunnel is cheapest in any ground. The same may be true of a single draw in good ground. Where the pipe, for any cause, cannot be supported by the bridge, and the approaches are exposed to ice and heavy shipping (a condition requiring strong fenders) and where the earth is propitious, it may be cheaper to tunnel the entire river, as was done at Malden bridge.

Where the channel may be obstructed by temporary piling, and where the requirements as to preserving the channel are not burdensome, a siphon is undoubtedly the cheapest, as in the crossing of Island End River, now under way. It is needless to say that a tunnel is always the best.

In these tunnels it has been demonstrated that in good clay, and in good clay only, a tunnel can be advantageously driven without a shield under compressed air; that the segmental lagging, as used by Mr. Haskin, is an easy, economical and stable method; that breaks, even in bad ground; are neither necessarily dangerous nor prohibitively difficult; that a large tunnel, with concrete between the pipe and the lagging, although more costly than a smaller tunnel grouted, makes much tighter work; that turned and bored joints are a delusion and a snare; that it pays to point up the joints on the inside of the pipe with cement; that cement joints give the best results, and are the cheapest and most convenient; that lathing and plastering the lagging with cement, while under compressed air, is an advantage.

Mr. G. H. Finn is the general manager, and Mr. L. J. Hirt was the chief engineer of the Massachusetts Pipe Line Co. Mr. W. E. Silsbee had immediate charge of the Malden and Charlestown tunnels, while Mr. E. C. Hayden had immediate charge of the River St. tunnel.

DISCUSSION.—Mr. Howard A. Carson.—The author has alluded to the tunnel crossing near the Malden bridge beside the new gas tunnel. On that there were some interesting experiences. Mr. Haskin was connected with that. During one serious blow-out the men were compelled to leave the tunnel, and the whole tunnel was filled with water in about an hour. This tunnel was at one point so close to the bed of the stream that, among other experiences, was the finding of a human skeleton in the mud at the top of the tunnel.

In the work on the Metropolitan Sewerage System there were six passages built under tidal estuaries, "siphons," we call them; one on the outer end of Deer Island, about 1,800 ft. into the sea; one under Belle Isle inlet; one under Shirley Gut; one under the Mystic River, at the point spoken of by the author this evening; one under the Malden River, and one under Chelsea Creek. In two of these cases, Belle Isle Inlet and the Malden River, the cofferdam process was used. At Malden River, the cofferdam was quite successful; that is, there were no serious mishaps of any kind; the trench was flooded once, but there was no serious trouble. At Belle Isle Inlet, however, where the cofferdam was also tried, the process, as carried on, was very unsatisfactory, the trench being flooded many times. It was finally necessary to make use of somewhat novel processes for finishing up the work.

As most of you remember, a novel method was used at the outer end of Deer Island, extending into the sea, and in crossing Shirley Gut, in sinking and connecting large pipes, made of brick and concrete. In these two cases, so far as rapidity and economy of the work was concerned, the results were superior to any of the other methods tried. At Shirley Gut the pipes were from 48 to 65 ft. long and over 8 ft. external diameter. They were made on the shore above high tide and moved down to low tide by means of blocks and rollers, as in moving houses. The ends were stopped up, so as to make the pipes water-tight. They were finally floated to their proper position, and methods taken to place them accurately on the bottom, join them together and afterwards remove the bulkheads.

Some allusion has been made to the East Boston tunnel. The work has now progressed, by the shield, something like 240 ft. The work is temporarily arrested, to put in the air locks. The general method employed there is almost precisely the same as that which was used on the subway tunnel in Tremont St. There are two drifts about 8 ft. square, made and timbered by an ordinary tunneling process. These drifts are about 30 ft. apart horizontally, outside to outside. In each of these drifts one of the side walls of the tunnel is built. The shield of the tunnel is later moved along, running on top of and resting on these side walls. The arch of the tunnel is built under the tail end of the shield, and, of course, joins with the side walls just mentioned. The invert is put in later. The hydraulic jacks, which push the shield along, react against cast-iron rods imbedded in the masonry of the arch, the same as on Tremont St. The main difference between the Tremont St. tunnel and that of East Boston is that in the latter case the arch is of concrete, while in the Tremont St. tunnel it was of brick. The cross-section in East Boston is considerably taller. The arch, instead of being very flat, is a semicircle.

Mr. C. M. Saville.—The Metropolitan Water Board has just completed a small tunnel between Chelsea and Charlestown. The contractor for the gas tunnels also did the work for the water board, and many of the men were employed on all of the work. The methods employed on our work were substantially the same as the author has so interestingly described. Two water shafts were sunk, one on each side of the channel and about 140 ft. apart. These shafts were about 65 ft. deep, and connected at their bottoms by a drift under the channel. The net inside diameter of each shaft and drift was 6 ft., and they were lined throughout with a foot of brick masonry laid in Portland cement mortar. The same shield was used as has been described by the author, but it was remodeled to work the heading, which had a gross diameter of about 9 ft. The material encountered was mostly sand containing considerable water. Much difficulty was encountered in keeping the shield on line and to grade, and, after the drift was about three-fourths completed, the shield was removed, and the remainder of the work was done with poling boards. After the tunnel was completed, a 24-in. ordinary cast-iron water pipe was laid in it by the maintenance department, and this pipe is now in use.

Mr. Robt. A. Shailer.—In the paper considerable stress was laid upon the use of compressed air for the purpose of keeping out water, and the thought has occurred to me that possibly you are not all familiar with the use of compressed air for the purpose of keeping clay from flowing or swelling, as it is usually termed.

We have been working for a number of years at Cleveland, O., constructing a tunnel 9 ft. inside diameter, with 12-in. brick walls, and 26,000 ft. long. The 22,000 ft. already completed have been constructed through a very soft, swelling clay; in fact, a material which it would be almost impossible to handle without compressed air. It contains no water to speak of, and if any of you were to go into the tunnel under our usual pressure of 28 to 30 lbs. of air, the clay would seem practically dry and quite stiff and hard, and it would be difficult to realize what it would be without the air pressure.

In sinking shaft No. 2, which is composed of cast-iron cylinders extending from above the surface of Lake Erie down nearly to the top of the arch, which is at about grade minus 94, and then underpinned with brick, we had occasion to take the air pressure off, and where square openings like windows were left for the purpose of breaking out into the drifts, I have seen clay flow in through said openings, and drop off in large chunks, while with the air pressure the clay appeared still and stable. Last fall, when one of the air locks in the tunnel got to leaking, so that the pressure was almost entirely lost, the clay flowed into the completed tunnel so as to nearly fill it up solid for some 20 ft. Mr. Carson has just spoken of our being about to put on the air pressure in the East Boston tunnel. We anticipate no trouble or danger from water in carrying on this work, but we do expect to have swelling clay, and if is to hold the clay that we are installing the pneumatic plant.

There is another use of air pressure in which we have had some experience, and that is for the dilution of explosive or marsh gas, as it comes into the tunnel. At Cleveland the whole ground is saturated with this gas, and chemical analysis shows that even with great care we have from ¾ to 1½% of this gas at all times in the air which the men breathe. If our pressure goes down, the percentage of gas becomes greater, so that we are reasonably sure that the use of compressed air tends to keep the gas out. The mixture of 5 or 6% of gas is exceedingly explosive, while a mixture of 9 to 10% is not. This may seem paradoxical, but it is true. What I have always feared is that, as the gas must flow into the tunnel practically pure, there must be somewhere between that and its dilution down to 1½%, a point at which the mixture is dangerous. We therefore watch our electric-wire connections, and take all the precaution we can and carry our

sawed from 2-in. plank and having an outer diameter of 7 ft. There were eight of these segments to a ring, and they were placed by spiking to the previous work with 7-in. spikes, each ring breaking joints with the previous one. This construction, which was the same as that used in the tunnel proper, was found to be exceedingly rigid.

A few feet above the point where the tunnel was to be started, the tubular form was changed and the "goose neck" was started. This consisted in constantly lengthening that diameter of the shaft parallel to the axis of the tunnel, on the side from which it was to start, until room enough was obtained to turn a 54-in. pipe, 8 ft.

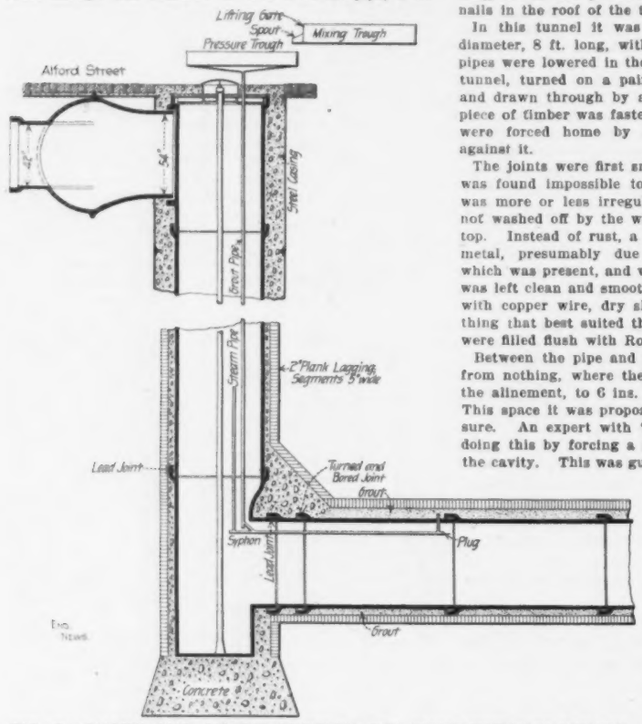

FIG. 2. SHAFT AND SHORT SECTION OF CHARLESTOWN SIPHON TUNNEL, SHOWING METHOD OF GROUTING CAST-IRON PIPE IN PLACE.

long into the tunnel. In this "goose neck" the sides were necessarily flat, but, being surrounded by stiff clay at this shaft, they showed no sign of weakness. At the Charlestown tunnel, however, the material was sandy and the side came in.

The shaft was driven 6 ft. below what was to be the bottom of the tunnel, and 4 ft. of concrete were put in as a foundation of the pipe that was to make the leg of the siphon. (Fig. 2.) The shaft on the Boston side was then sunk in the same way, and the tunnel started from that end.

In driving the tunnel a shield was used similar to the Greathead design, as shown by Fig. 3. The excavation was carried about 2 ft. ahead of the shield in good digging, and the latter was pressed forward by the hydraulic jacks, a, a, bearing directly against the lagging. This served a double purpose, pushing the shield forward and closing up the joints in the lagging, although, as the lumber was thoroughly dry when placed, it was found that the swelling of the wood made very tight work. The lagging was given a wash of cement after it was placed, and such leaks as showed were calked with wooden wedges and yarn, and by feeding dry cement into the holes, the escaping air under pressure carrying the cement with it.

North of the draw the tunnel ran beneath an ice guard, and the bottom of the piles had to be cut off in the heading. This occasioned no great hardships, while the driving was in clay, but about three-quarters of the way across the river a streak of silt and sand was struck, which, being only 7 ft. thick between the top of the tunnel and the bottom of the river, followed the piles into the heading and stopped the work.

Poling planks were driven ahead, similar to those shown in Fig. 4, and cut so that the ends could be worked back on the cutting edge of the shield. Gunny sacks, filled with horse manure, sawdust, etc., were thrust into the cavities, and, as soon as the holes were plugged, they were quickly plastered with clay. The material ahead was then excavated and the shield pushed forward. The surrounding material was so soft and unstable that the lateral movement of the shield was scarcely controllable, the whole structure moving toward the side that caved in.

As a whole, however, after the soft material was passed and the transit line extended, the headings met within 0.42-in. The tunnel was allowed to fill with water and to remain filled for a few days to give the woodwork a chance to swell and to permit the silt to pack about the lagging.

To a great extent this closed the remaining leaks, so that a 3-in. pulsometer easily kept the water down after the air pressure was removed. After pumping the tunnel out, a cross-section was taken, and this, compared with the one taken before, showed that the tunnel had flattened about ½-in., thus proving that the lagging would not be permanent of itself.

In giving the line of the tunnel the distance between the shafts was triangulated and the direction transferred to the tunnel by means of two wires which passed through holes tapped in the air lock. This gave a base line about 4 ft. long, which was produced into the heading by means of nails in the roof of the tunnel.

In this tunnel it was decided to lay pipe 54 ins. to diameter, 8 ft. long, with turned and bored joints. The pipes were lowered in the shaft on the Boston side of the tunnel, turned on a pair of skids in the "goose neck," and drawn through by an engine at the other shaft. A piece of timber was fastened to the tunnel, and the joints were forced home by a hydraulic jack which rested against it.

The joints were first smeared with sal-ammoniac, but it was found impossible to get them tight, as the turning was more or less irregular, and what sal-ammoniac was not washed off by the water, refused to rust as it did on top. Instead of rust, a soft black coating formed on the metal, presumably due to the sulphurreted hydrogen which was present, and when this was wiped off the metal was left clean and smooth. The leaky joints were calked with copper wire, dry shingles, jute, cold lead and anything that best suited the particular leak, and the joints were filled flush with Roman Orchard cement.

Between the pipe and the lagging was a space varying from nothing, where the lagging was cut out to improve the alinement, to 6 ins. at a point diametrically opposite This space it was proposed to fill with grout under pressure. An expert with "experience" submitted a bid for doing this by forcing a mixture of lime and cement into the cavity. This was guaranteed to do the work, the lime being "greasy" and acting as a carrier for the cement. Meanwhile the engineers made a series of experiments as to the action of different cements and mixtures under conditions similar to those on the work. In each case grout was made, and poured into a pan containing salt water. All the cements to which lime had been added remained like so much mud; some of the cements with high records caked like dirt, while some of the cheaper low-grade cements took a quick initial set, which, of course, was what was wanted in this case. It was found that one brand of cement, into which steam was turned, became soft and slippery like paste and set very quickly. A jet of steam, acting on the principle of an injector, was accordingly used, the grout being mixed in a trough at the top of the shaft and carried down by 1½-in. pipes. (Fig. 2.) In laying the 54-in. pipes, bulkheads had been built between the pipe and the lagging every 25 ft. or more. Each length of this pipe had a hole for a ¾-in. pipe tapped in its top, and into these holes the grouting pipes were successively introduced, the progress of the grouting being watched through the holes in the succeeding pipes, and these holes being plugged when the grout began to appear.

The steam jet was in the shaft, and as the reach from it to the introducing hole became greater and the time of changing forward became longer, the injector became plugged with cement and was finally abandoned, the pressure due to the height of the mixing trough being used and the pipe washed out with clean water after each succeeding run. When the distance became too great to get the desired pressure by this method, the grout was mixed in the tunnel and injected by means of a force pump.

From time to time the plugs were withdrawn from the top of the tunnel, and the grout cut through with a drill to determine its set and fill. The best results were obtained when the steam jet was used, the cement seeming to have swollen in setting. Where the cavity was not entirely filled, the force pump was used to finish the work. In the shafts the pipes were concreted as fast as placed, the steel casing being left in.

In driving the tunnel the water was taken care of by two 4-in. pulsometers, and by two steam ejectors rigged tandem; that is, one at the bottom of the shaft and one halfway up. On the completion of the tunnel the water of condensation and leakage amounted to 4½ bbls. per day.

The tunnel was finished Dec. 1, 1899, and gas was turned on about Dec. 3. The drippage decreases to 2½ bbls. a day in summer, and increases to 19½ bbls. a day in winter.

CHARLESTOWN TUNNEL SIPHON.—The Charlestown tunnel was commenced as soon as the air lock could be

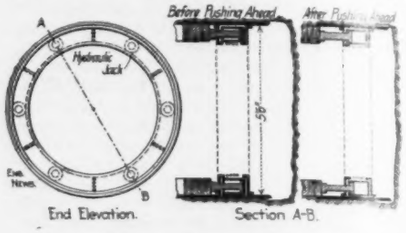

Fig. 3. Shield for Driving Malden Siphon Tunnel with Segmental Wood Lining.

spared from the Malden tunnel. The shafts were sunk in midstream from temporary platforms, and did not differ materially from those of the Malden tunnel.

For convenience in handling the water in working from both shafts at once, the summit was placed between the shafts. This tunnel was driven without a shield, under an air pressure of 28 lbs., the clay being stiff enough to maintain the heading except in one part where gravel was encountered in the roof. Here poling boards, horse manure, etc., were used, as in the Malden tunnel, except that the poling planks, were worked back on the lagging when cut off, instead of the shield as in that tunnel.

The "goose neck" was turned in less favorable material in this tunnel, and on removing the bracing the flat side broke in. After ineffectual attempts to patch it, a concrete lining was placed, as thick as would allow the introduction and turning of the pipe. These were common bell and spigot pipe, 12 ft. long, and were made up with cement joints. The pipe was placed in the shaft on the Boston side first, and the concrete was brought up to the top of the steel caisson. The tunnel pipe was then started at that shaft and laid toward the Charlestown side.

A 3-in. pipe, provided with open tees, was suspended in the roof of the tunnel, and each length of 42-in. pipe was concreted as it was placed. The concrete was mixed over the shaft and dropped through a chute to a car that ran inside the pipe already laid, and was then dumped, remixed and rammed by men standing alongside of the pipe. (Fig. 5.) Around the joints the concrete was made stronger and greater care was used to make it impervious to water. When the pipes were all laid and concreted, the 3-in. pipe in the roof was flushed with grout. The shafts were protected by circular fenders, and also by outer channel fenders.

This tunnel was completed about Jan. 1, 1900. It is the best one of the three, the only objection being the necessity of pumping two drips.

RIVER ST. TUNNEL SIPHON.—In the River St. tunnel, the Brighton shaft was sunk 90 ft., and the Cambridge shaft 60 ft. It was commenced by sinking the Cambridge shaft without the steel caisson and running the tunnel in 80 ft. without compressed air. At that point the clay changed to a vein of sand, and the heading came in, filling the tunnel for 40 ft., and destroying the cross-section.

The Brighton shaft was then sunk to a depth of 90 ft. before enough clay was found to turn a "goose neck." The old shield could not be used, because it was not large enough, and on account of the scarcity of steel it would have taken too long to procure a new one. As matters turned out it would have been better to wait for a shield, but the borings seemed propitious and a heading was

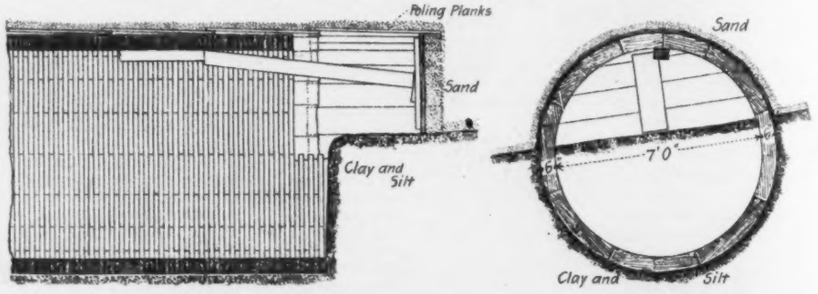

FIG. 4. SKETCH SHOWING POLING-BOARD METHOD OF DRIVING MALDEN SIPHON TUNNEL.

formers are of the Stanley oil-insulated and water-cooled type.

The station building, 275 × 40 ft., has walls of rubble masonry, with steel roof trusses and galvanized corrugated iron covering. A traveling crane, of a capacity to lift any weight in the building, runs the entire length. Beneath the floor of the building a subway is built containing all the wires which are led to the switching devices at the center of the station.

A commodious and well-equipped dwelling house has been erected near the station building for the accommodation of the men.

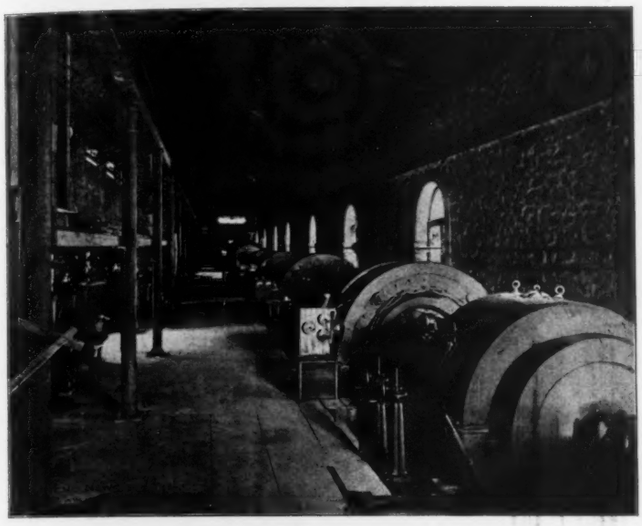

FIG. 6. INTERIOR OF COLGATE POWER STATION.

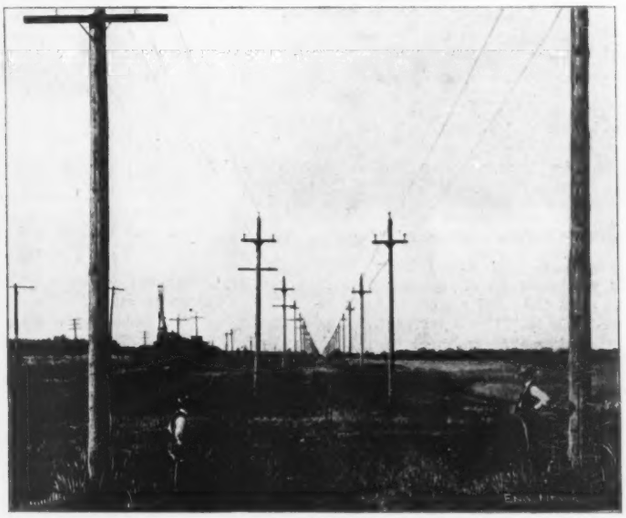

FIG. 7. VIEW OF THE POLE LINE.

In connection with the main supply of water an additional supply is being arranged for which is independent of the main river. This is formed by damming up Dobbins Creek to form a lake, which will cover about 90 acres and which has been named Lake Francis.* The dam will be an earth fill 75 ft. high. This is now in course of construction, the material forming the dam being hydraulicked into its place. The surface of the lake will be 1,000 ft. above the power-house, and distant therefrom 2¾ miles. The lake will be connected with the penstock by 9,000 ft. of 36-in. diameter wooden stave pipe and about 3,000 ft. of steep grade flume.

The Nevada power-house is 7½ miles from Colgate, and supplies power to various points in Nevada County. The plant at this place consists of four 500-HP. generators which deliver a two-phase current of 133 cycles and 5,000 volts. This plant is unique, in that two different heads of water may be used on the generators. The ordinary supply, from a flume leading from the Yuba River, has a head of 200 ft. The high head supply has a head of 800 ft., and is delivered from reservoirs with a capacity sufficient to discharge 40,000 miners' inches for 24 hours. Each generator has two water wheels upon its shaft, one using the low pressure water and the other the high pressure.

The Brown's Valley plant, about 9 miles from Colgate, supplies power to Marysville and mines at Brown's Valley. The current generated is two-phase, 60 cycles, and at 2,400-volt pressure. The water wheels operate under a head of 392 ft.; Pelton wheels being used. The generators, of which there are two, are of 350 K-W. capacity, and are run at 400 revolutions per minute. Step-up transformers, of the Stanley oil-insulated and water-cooled type are used to transform the current to the line pressure of 16,000 volts.

The three power-houses above described are all connected with each other, so that the three form a single power station, and the supply of current from any one can be used to help the load on the other in case of necessity.

THE TRANSMISSION SYSTEM AND THE LINE.

The line from the power-house at Colgate to Oakland, as before noted, is somewhat over 142 miles in length. At present the line voltage is 40,000, but this will be increased to 60,000 volts under increased load. Step-down transformers are used at Woodland, Wheatland, Napa, Oakland and at the sub-stations on both sides of Carquinez Straits, which deliver current at the various voltages required at the places mentioned. At Oakland the current is transformed to 2,000 volts, which current operates three General Electric Co. synchronous motors direct-connected to 550-volt direct-current generators of 450 K-W. each. This current is used on the lines of the Oakland Transit Co., which owns all the street car systems of Oakland, Alameda and Berkeley, with a total extent of 126 miles. A branch line carries power to the Oakland central station of the Standard Electric Co, of California. which in turn delivers current to the Oakland Gas, Light & Heat Co.

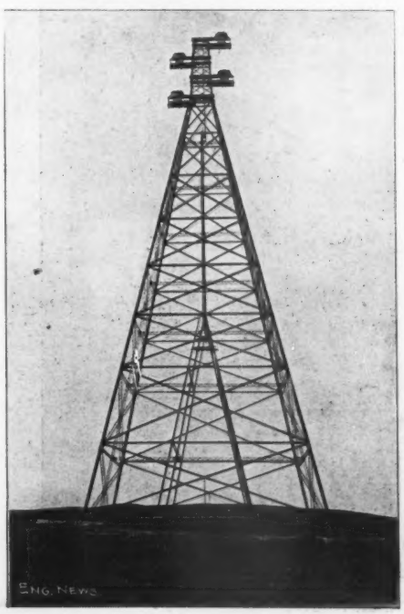

Fig. 9. Main Tower; Carquinez Crossing; 225 ft. high.

The pole line for the entire distance is in duplicate, the two lines of poles being in general about 25 ft. apart. This duplication was made as an insurance against interruption of the service by accident. One line is of No. 00 medium hard-drawn copper throughout, while the other line is of aluminum from Colgate to Suisun, and of copper for the remaining distance. This was done to avoid the corroding effect of the salt air on the aluminum, in the vicinity of San Francisco Bay. The aluminum cable is composed of seven strands of wire having in total the conductivity of No. 00 copper wire, and was made by the Pittsburg Reduction Co. The standard distance from pole to pole is 132 ft.

The poles for the main line are of Oregon red cedar, 14 ins. diameter at the butt and 8 ins. at the small end, and 35 ft. long. They were set one-sixth of their length in the ground, the ground end being painted with carbolineum avenarius to prevent decay. The cross-arms are arranged to place the wires at the apices of an equilateral triangle whose sides are 42 ins. in length. The upper end of the pole was coned and bound with six turns of iron wire. The cross-arms were treated with hot asphaltum and coal tar and the upper portion of the poles was painted with tar paint.

The line insulators used were made under the patents of Mr. Sterling, the Superintendent of the Bay Division. The pins were of California eucalyptus, boiled in linseed oil.

TELEPHONE LINE.

The telephone line consists of a three-strand aluminum cable having the conductivity of a No. 9 copper wire, and is carried on double-petticoated glass insulators on a cross-arm placed 5 ft. below the power line. The telephone line itself is not transposed, but instead, the power lines are transposed every mile and the very successful operation of the telepnone service speaks well for this arrangement. Much credit is due Mr. T. E. Theberath for suggesting this idea.

THE CROSSINGS AT BEAR RIVER, PUTAH CREEK AND SACRAMENTO RIVER.

The span of the wires at these three points was about 1,000 ft. in each case, and tall poles were necessary. At Bear River and Putah Creek the top of the poles was 80 ft. above the ground level, those at Putah Creek being set in a mass of concrete and guyed. At Bear River, owing to the fact that the surface of the ground was under water, the poles were each supported by four piles driven battering. At these two places the poles were single sticks.

At the Sacramento River, while the span was but 1,000 ft., the height of the poles was greater owing to the fact that the river is navigable by steamers with smokestacks 60 ft. high, and also that at high water the water surface is about 10 ft. higher than the surrounding land surface. This made it necessary to use poles 125 ft. long above the ground, a safety factor of 4 being used in the copper wire of the span. The poles were made in two sections, supported by a base of concrete and four piles at the base and guyed with four wires at two different points. The upper set of guy wires have 6 × 6-in. timbers, 20 ft. long, placed near the pole, the guy wires being attached to the ends of the timber. This was done for insulation. The guy wires were attached to timber "dead men" buried 10 ft. in the ground.

*This lake will contain, when full, sufficient water to run the entire plant eight days.

inlet pipe straight up to the heading, so as to dilute the gas there.

Compressed air has been used to retard the flow of water into tunnels where the head was so great that sufficient pressure could not be maintained to keep the water out entirely. Under these conditions the work of necessity must be carried on very slowly and at great expense.

(The discussion was closed by Mr. Cummings with a description of the siphon at Everett, Mass., which was described and illustrated in Engineering News of July 4, 1901.—Ed.)

THE 142-MILE ELECTRIC POWER TRANSMISSION PLANT OF THE BAY COUNTIES POWER CO., CALIFORNIA.

By J. D. Galloway.*

The completion of the transmission lines of the Bay Counties Power Co., in the early months of this year, marks an important advance in the long-distance transmission of power by electricity. From the power-house on the Yuba River, in the Sierra Nevada Mountains, to the city of Oakland, the distance by way of the line is 142 miles, and power is now being delivered in that city for lighting and street railway purposes. Under arrangements with the Standard Electric Co., of California, whose power plant is not completed, power is also being delivered to San Jose over the company's lines, making the total distance of transmission somewhat over 184 miles.

In connection with the construction of this long line there were several features of great engineering interest, the most notable of which is the crossing of the Straits of Carquinez, where the suspended cables have a span of 4,427 ft.

The Bay Counties Power Co. was formed by the consolidation of the Yuba Electric Power Co. and the Nevada County Electric Power Co., two companies under practically the same management, with plants on the South and North Forks of the Yuba River. The initial plant was that of the Nevada County Electric Power Co., which was established on the South Yuba. Work was commenced in July, 1895, and the plant was in operation in February, 1896, delivering 1,000 HP. to Nevada City and Grass Valley for lighting purposes and to various mines for power purposes. In 1897 the capacity of this plant was doubled.

The plant of the Yuba Electric Co., originally the Yuba Power Co., was established in April, 1898, on the North Fork of the Yuba River at a point (about eight miles from Smartsville) where an irrigation canal dropped some 300 ft. This plant was notable for the quick work of the installation, the entire plant being established in four months and five days, 1,500 HP. being developed. This plant delivers power to Marysville, and to mines at Brown's Valley. In less than a year, the demands on the plant led to the building of a larger and more comprehensive system at Colgate. Machinery for the generation of 5,000 HP. was installed, and a line was built to Sacramento, 61 miles distant, and to several gold dredges near Oroville. The moving spirit in both of these companies was Mr. Eugene J. de Sabla, Jr.

In June, 1900, the Bay Counties Power Co. was formed by the consolidation of the two above-mentioned companies, and the line to Oakland was projected. In somewhat less than ten months the power plant at Colgate was doubled in capacity, the double pole line constructed 142 miles to Oakland, and the transformer plant and crossing built at Carquinez Straits. On April 27, 1901, the current was turned into the power-house at Oakland.

At present machinery is installed at the various plants capable of delivering a total of 17,000 HP., and water power is available for increasing this by 13,000 HP.

*Consulting Civil Engineer, 206 Kearny St., San Francisco, California.

Branch lines are built, or are in process of construction, to Woodland, Vallejo, Martinez, Benecia, Napa, Petaluma and Santa Rosa, while various manufacturing establishments are served from the transformer stations at Carquinez Straits. From the station at Oakland, a line about a mile in length leads to the Oakland Station of the Standard Electric Co. of California.

THE POWER-HOUSES IN THE SIERRA NEVADA MOUNTAINS.

There are three power stations situated on various forks of the Yuba River, as noted above, the location of which is shown on the accompanying map, Fig. 1. The plant which supplies power to the Oakland line is located at Colgate, about 36 miles from Marysville, the river being at this point about 600 ft. above sea level.

The dam across the Yuba River is of timber crib construction, 40 ft. high at the deepest point and about 250 ft. wide on the crest. The controlling gates are set in rubble masonry. In winter the water sometimes reaches a depth of 10 ft. over the crest, and the bed of the river has filled up entirely above the dam with gravel.

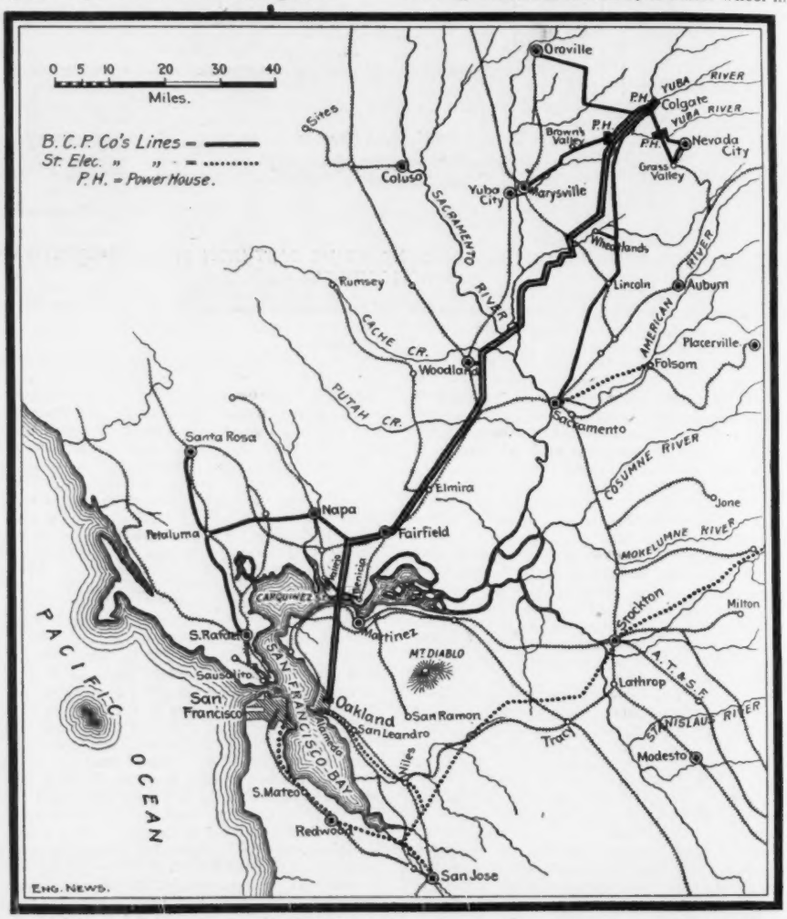

FIG. 1. MAP SHOWING POLE LINES AND DISTRIBUTING STATIONS OF THE BAY COUNTIES POWER CO., OF CALIFORNIA.

The distance from the dam to the penstock on the mountain above the power-house is seven and three-quarter miles. The flume which carries the water from the dam to the penstock has a uniform section, 7 ft. wide and 6 ft. deep. The bottom and sides are of 1½-in. plank, with 4 × 6-in. posts and 4 × 8-in. sills, the bents being 3 ft. c. to c. The grade of the flume is 13 ft. to the mile and about 8,000,000 ft., B. M., of lumber was used in the construction. This work, while difficult in places, offers nothing unusual in the way of flume construction.

The penstock is built of rubble masonry, with a lining of concrete 1 ft. thick. The gates to the pipes are inside the penstock, while manhole pipes, protected with conical hoods, are placed just outside. The penstock is arranged to accommodate five lines of pipe, but at present there are but four lines in place. From the penstock to the power-house the distance along the slope is 1,760 ft., the static head in the pipes being 715 ft., and the average angle of slope about 24° from the horizontal. The contour of the pipe is, however, somewhat irregular, being considerably steeper in parts.

The upper 800 ft. of the pipes is built of riveted sheet steel, the thicknesses being No. 12, No. 10 and No. 7, in about even amounts. The lower 960 ft. of the pipe is of cast iron, varying from ¾ in. to 1¾ ins. in thickness.

Commercial shapes were used, the lengths being 12 ft. When the pipe passed over bed rock it was anchored with steel straps, and at other places it was set in masses of concrete.

The pipes, of which there are four, are each 30 ins. inside diameter, and the effective head of water is 695 ft. The flow is at the rate of 8 ft. per second, with a pressure at the receiver of 300 lbs. per sq. in.

The water wheels were made by the Risdon Iron & Locomotive Works, of San Francisco, and are the common type of tangential water wheels. Each generator is driven by a water wheel mounted on the same shaft. The water from the pipe lines enters a receiving pipe, which lies parallel with the power-house and is taken from the receiver in 14-in. pipes to the water wheels. At present the generators for the Oakland line are controlled by hand, but Lombard oil governors are to be installed.

The installation of the present station at Colgate consists of two 2,000 K-W., three 900 K-W. and one 720 K-W. Stanley generators, each direct-connected to a water wheel. They are three-phase, 60-cycle, 2,400-volt, inductor machines. There are eight 300 K-W. and four 200 K-W. transformers, the primary winding being for 2,400 volts, and the secondary winding to 24,000 volts. In addition to this there are ten 700 K-W. transformers with primary winding for 2,400 volts and secondary winding arranged to give 40,000, 50,000 and 60,000 volts when connected up in star. All of the trans-

At these three crossings the wires are not attached rigidly to the insulators, but are carried over wooden sheaves of 6 ins. diameter, made of lignum-vitae and grooved to fit the wire. The sheave has a steel shaft, each end of which is carried on one of the regular line insulators.

At a point near the Sacramento River it was necessary to support the line poles for a short distance upon piles driven 20 ft. into the ground. This was done as a protection against possible wash from the flood waters of the river.

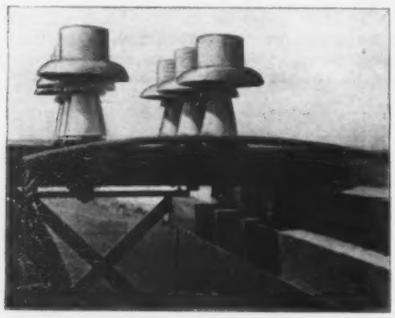

Fig. 13. Saddle Insulators in Place on Tower.

THE CARQUINEZ STRAITS CROSSING.

Just before the combined waters of the Sacramento and San Joaquin Rivers enter San Francisco Bay, they pass through a narrow channel varying from half a mile to a mile in width and about five miles long. On both sides of the channel lie steep bluffs and hills, those on the south side being considerably higher than those on the north side. The channel is called the Straits of Carquinez, and is bordered by grain warehouses and the tracks of the Southern Pacific Railroad on the south side. Since the high voltage carried on the line prohibited a crossing below the water at that pressure, it became a question of either installing transformer stations on both sides of the Straits to first step down the voltage by transformers and then after its passage under the river, to step it up again; or to carry the wire across the Straits as an overhead crossing. The danger to cables lying in the bed of a swift river frequented by large ships, the cost of the transformer stations and the constant loss due to the two transformations led to the adoption of the overhead system, although there was no precedent for determining the behavior of cables of such a long span in a heavy wind.

The design of the cables was left to the John A. Roebling Sons Co., the primary condition being their electrical conductivity, since they were designed to carry the current and not to merely support a copper conductor. They were made of "plow steel," of a breaking strength of 192,000 lbs. per sq. in. As constructed, the cables are ⅞-in. diameter and are composed of nineteen strands of wire, with a total cross-section of ½ sq. in., making the breaking strength of the cable 96,000 lbs.

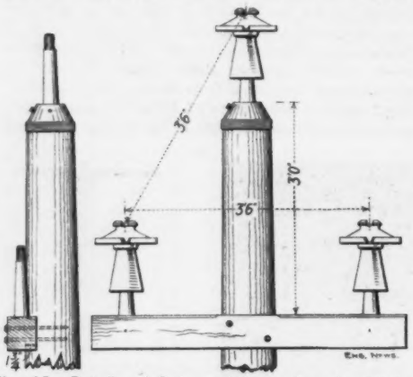

Fig. 16. Details of Pole and Cross-Arm for High-Tension Transmission.

Since the largest ships come up the river to the adjacent wharves to load wheat, it was necessary to provide a clearance of at least 200 ft. under the lowest wire. It was decided to adopt a safety factor of four in the cables when in a static condition, and with the above data, the curve of the cable was determined.

The problem of the design of the crossing, together with the towers, anchorages, etc., and the contract for the erection, was given to the Pacific Construction Co., of San Francisco, of which Mr. F. A. Koeditz is engineer. After several surveys of various points, the crossing was located about one mile west of Port Costa.

The general design is shown by the drawings. The main span of the cables is 4,427 ft., with a deflection of 227 ft. from the highest elevation. The lowest wire is 208 ft. above the water at the lowest point of the wire. On the north side a leaning tower was placed, as shown, in order to deflect the cables to the ground and to shorten the shore span. The cables pass over the towers on grooved rollers and the deflection angles are the same on both sides in order to give a vertical reaction. The cables, of which there are four, are 20 ft. apart horizontally, and on each side 20 ft. apart vertically. From one cable on one side of the tower to the nearest cable on the opposite side, there is a vertical distance of 10 ft. This arrangement was used in order to allow for considerable swing at the center of the cables without there being a possibility of contact. While but three cables were necessary, four were employed in order to have one in reserve.

Each cable exerts a pull of about 24,000 lbs.

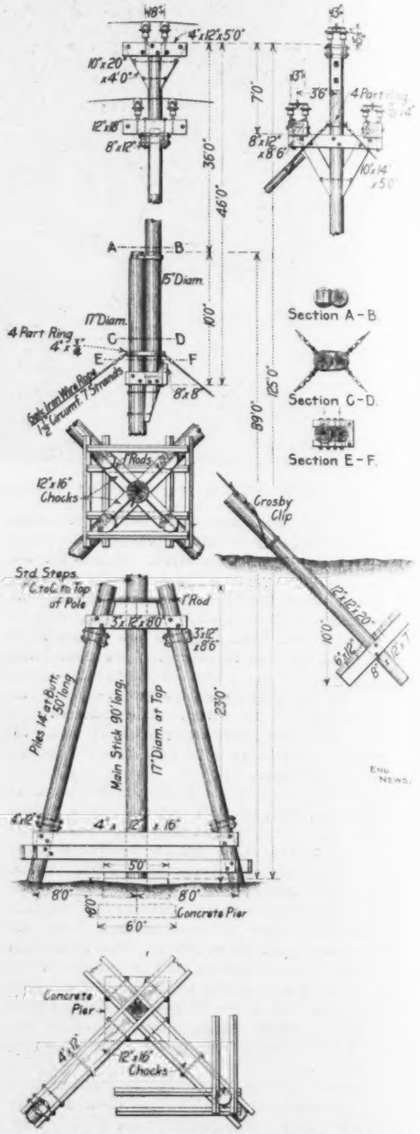

Fig. 17. Detail of Mast; Sacramento River Crossing.

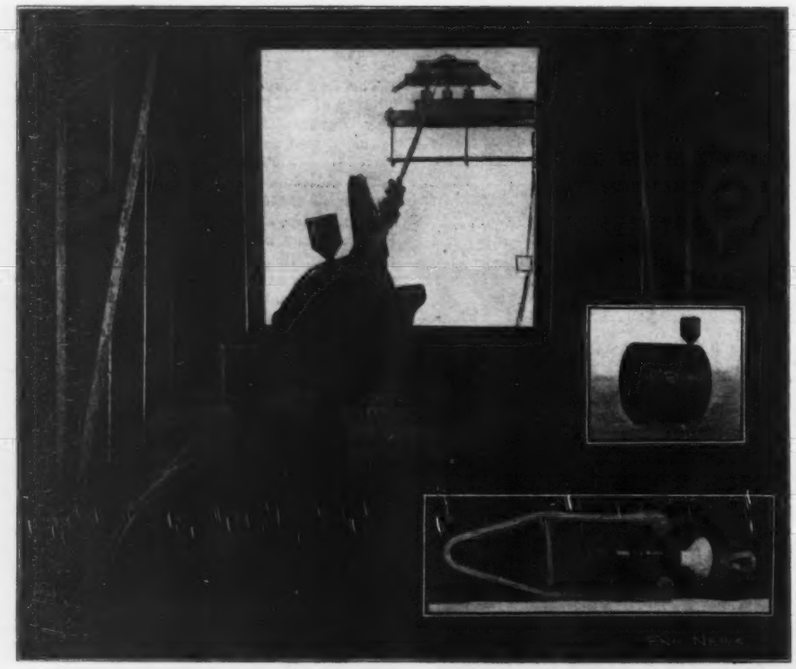

FIG. 15. STRAIN INSULATORS IN CABLE ANCHORAGE HOUSE.
(Parts of Strain Insulator Shown at the Right.)

on the anchorages, and since they carry the current, it was necessary to insulate them from the earth. The first strain insulators designed were of porcelain, of about the same shape as the micanite parts used in the ones adopted, but the manufacturer failed to turn out an article that would stand the physical test. Some that were tested broke on the first application of the testing machine. The insulators shown in the drawing were then designed, the essential insulating material being micanite, a preparation of sheet mica and shellac formed under hydraulic pressure. This was surrounded by an insulating oil in a copper tank. Two of these insulators are used at each anchorage for safety.

The cast-iron saddle which carries the cables rests upon a wooden platform covered with tarred canvas and provided with a gutter and spout. This platform, in turn, rests upon six porcelain insulators, with triple petticoats, the insulators being supported by steel pins passing through the timber supports. The whole is supported at a distance from the ironwork of the towers by wooden arms. A suspended platform is provided for inspection. These insulators under the saddles, together with the strain insulators, were designed for the purpose by Mr. R. H. Sterling, Superintendent of the Bay division.

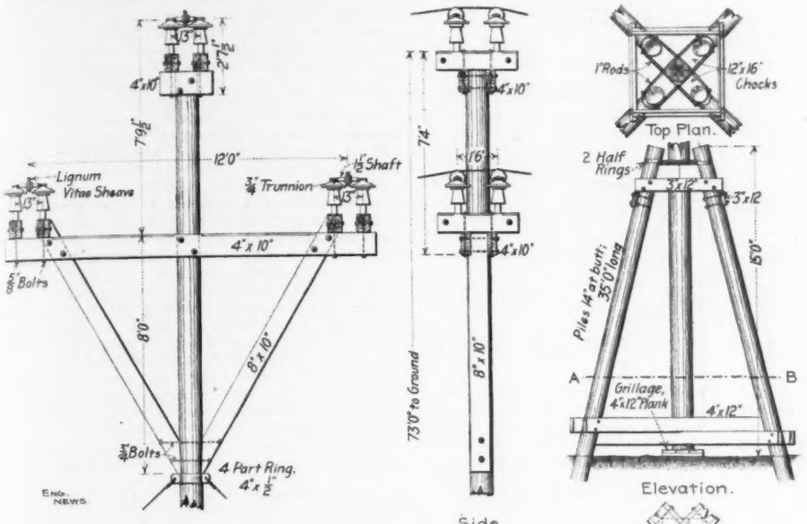

FIG. 18. DETAILS OF CABLE-CROSSING AT BEAR RIVER.

The cables at the anchorages are provided with a long turnbuckle for adjustment, and a nest of steel springs to take up any sudden motion. The cable is attached to a large sheave at the outer end of the insulators, over which it passes, the end being bound to the cable with clips. The anchorage is a mass of concrete in which are embedded the necessary beams and rods.

The whole of the insulators and attachments are enclosed within a frame house, provided with a large plate-glass window in front, through which the cable passes by an opening 9 ins. in diameter.

The towers were built of steel throughout. The legs are of latticed channels and the bracing is of four angles latticed. Rods were used only in the horizontal bracing. The legs rest upon concrete blocks founded on the underlying rock. A ladder is provided on each tower. All ironwork was painted with silicon graphite paint and the timbers supporting the cables were oiled, filled and varnished with spar varnish.

Each of the cables were made in one length and arrived on a large reel. They were unloaded from the cars to a small wharf on the south side of the Straits. From there the end was drawn up the hill, over the south tower and fastened to the anchorage. The reel was then placed on a barge and towed across the river, the cable being allowed to sink to the bottom. The reel was landed on a small wharf on the other side, and the remaining portion of the cable was unreeled. A line was then passed over the tower and the cable was drawn to position by a hoisting engine stationed near the leaning tower. The arrangement of the blocks and engine are shown in the sketch. The four cables were placed in position in five days. The work of erection was under the direct charge of Mr. Frank Fields, general foreman, and Mr. Frank M. Butler, of the Pacific Construction Co., and was successfully carried out without mishap.

After erection, the cables were oiled with Lucol oil by a man in a traveling carriage. The carriage consisted of a platform 3½ × 5 ft., hung from the cable by iron straps connected to two roller-bushed sheaves. The platform, which was hung 5 ft. below the cable, was provided with a railing. The whole was moved in and out by a man at the tower, who operated a windlass and line, the line being supported every 100 ft. by a traveling hanger.

It is of interest to note that the cables are practically stationary in the highest winds. No particular observations have been made under such circumstances, but with a wind of 25 miles an hour an oscillation of about 2 ft. and of long period can be observed from below. It is probable that the principal effect of the wind acting on the entire length of 4,427 ft. is to deflect the cable somewhat to one side. With the slight morning wind the cable is subject to considerable tremor and becomes charged with static electricity, but with the coming up of stronger winds, the tremor in the cable disappears.

THE TRANSFORMER STATIONS.

At the Oakland end of the line the transformers and generators were placed in the Piedmont Power Station of the Oakland Transit Co. At Carquinez Straits, a transformer station, 34 ft. 6 ins. × 55 ft., was erected on each side of the river, near the cable anchorages. The buildings are of steel frame, with timber purlins, and are covered with galvanized corrugated iron. On the roof a double layer of iron was laid 6 ins. apart vertically to prevent condensed water from dripping on the machinery. The floors are of wood in two layers. The only feature of particular interest in the design of these buildings was the method of introducing the high-tension wires. Two lengths of 24-in. standard salt glazed sewer pipe were framed into the walls on an incline; the inner end being covered with glass.

The equipment of these stations consists in each case of four 500 K-W. oil-insulated and water-cooled Stanley transformers, one being in reserve. The line voltage is stepped down to 5,000 volts. The secondary current is distributed from a low-tension switchboard by means of two circuits at each station to the various towns within a radius of 5 or 6 miles. The most interesting details in these stations are the switches, designed to handle a pressure of 60,000 volts and a current of 25 amperes. They are a combination of switch and fuse, the fuse being mechanically released when it is desired to open one of them, and the arcing taking place at the end of the fuse. The lightning arresters are also contained in these buildings, besides the electrically-driven pumps for circulating the water in the transformers.

A plant for pumping water from the level of the railway tracks near the river has been in-

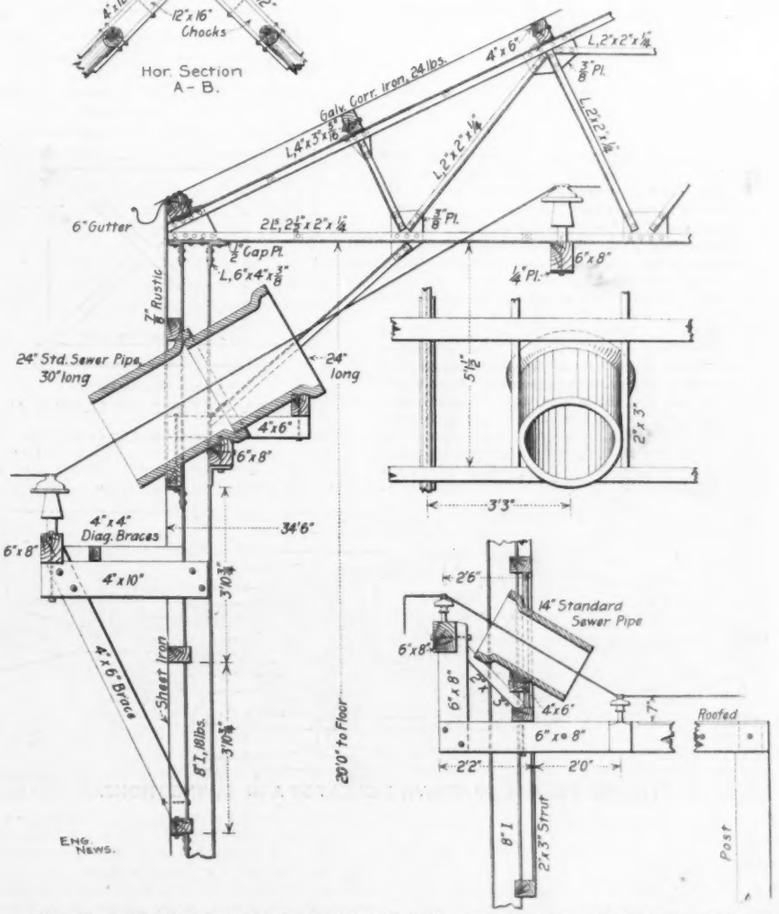

FIG. 19. WIRE ENTRANCES TO TRANSFORMER STATION AT CARQUINEZ STRAITS.

stalled and a 6-room cottage has been built for the accommodation of the station tenders.

The main office of the company is at 324 Pine St., San Francisco. Mr. Eugene J. de Sabla, Jr., is President and General Manager, and Mr. F. M. Ray, Assistant Manager. Mr. L. M. Hancock is General Superintendent of the company. Mr. T. E. Theberath is Superintendent of the Yuba division, Mr. Geo. Scarfe is Superintendent of the Nevada division, and Mr. R. H. Sterling is Superintendent of the Bay division, in which capacity he has had entire charge of the construction of the line from Wheatland to Oakland. The present writer had charge of the construction of the Carquinez Straits crossing for the company, and also designed the transformer station buildings and the crossings at the Bear and Sacramento Rivers.

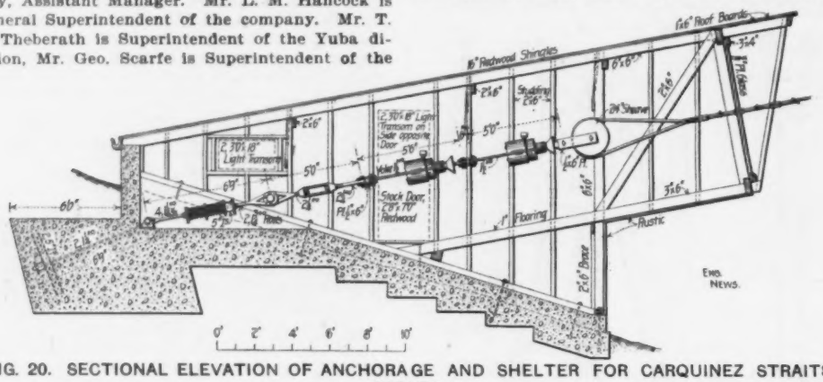

FIG. 20. SECTIONAL ELEVATION OF ANCHORAGE AND SHELTER FOR CARQUINEZ STRAITS CABLES.

TRANSMISSION LINE CONSTRUCTION OF THE BAY COUNTIES POWER CO.*

By C. E. Dutcher.

All poles are set 1 ft. deeper in the ground on angles. The poles are shaved the entire surface of the top to a point 6 ins. below the bottom cross arm, and are painted with a tar paint put on hot, which gives it the glossy finish that is the identifying characteristic of the Bay Counties lines. The butts are saturated with hot carbolineum, imported from Germany, for a distance of 2½ ft. below what is known as the "air line" and 1 ft. above. The poles are framed and cross armed so that the three wires of each three-phase circuit form an equilateral triangle 36 ins. on the side and 42 ins. on transpositions, each line being transposed every mile. This transposition consists of one-third of a turn or spiral, that in one line being to the right, while that of the other is to the left. In other pole lines it has been found that although the pins may have been amply separated for straight-line work, the twisting of the lines at the transpositions brought them so near together at the center of the transposition span that they have been short circuited even by such small birds as meadow larks. This occurrence has been avoided in the lines under consideration by making the sides of the triangle 6 ins. greater on transposition arms than on ordinary runs, which brings the minimum separation between transposition poles down to 36 ins. The poles are of Oregon cedar, round, and in length as follows:

Height, ft.	Top, ins.	Butt, ins.	Depth in ground, ft.
25	8 × 8	12 × 12	5
40	9 × 9	14 × 14	6
45	10 × 10	15 × 15	6½
50	11 × 11	16 × 16	7½
60	12 × 12	18 × 18	8

*Extracts from a paper read at the fifth annual meeting of the Pacific Coast Electric Transmission Association at San Jose, Cal., June 18 and 19, 1901, and published in the "Journal of Electricity, Power and Gas." In comment upon these extracts it may be remarked that only those parts of the paper are retained which describe features of the transmission line that are not described in the article in the preceding paper by Mr. Galloway.

The poles are taken from the cars and placed on skidways convenient to frame and again loaded on wagons. This is done by the use of spike skids, a running line, a snatch team and one man. This equipment is all that is necessary to load any kind of a pole on to any wagon. The poles are taken along the pole line and delivered with the top up hill and the butt of the pole at the hole, which procedure does away with the handling of a pole the second time. After the cross arm is put on and the pins are nailed in, the pole is ready to set. This is done in three lifts by eight men who are trained to work together and who pike and tamp in 40 poles per day. Most of the lines are over a mountainous country altogether inaccessible to a truck derrick, and the skill which the men have acquired in piking-in poles has become so remarkable that my preference is most decidedly for piking rather than derricking. In piking each man knows his position and he does his work with mechanical precision without a word being said or a motion made. In the first lift the pole is placed on to a 6-ft. deadman, as the short crosshorse is termed; in the second lift the pole is raised by the short pike men, while the third lift puts it into the hole; when it is caught by two long 16-ft. pikes, one on each side, while in the vertical position. Then the two 14-ft. pike men walk around to the sides of the pole and stay it so that by the time the "straw boss" has reached the butt of the next pole to sight the line, the short pike man is off to the side at right angles to the line, when the pole is finally set by the plumb-bob and tamped in.

Pole-hole digging is one of the most important portions of line construction, and it forms a trade by itself which few become proficient in. All pole positions are "spotted" by one man, who does no other work. He carries a pick and shovel and digs a hole about a foot deep on the exact spot indicated by the surveyor's stake, the diameter of the hole being greater than that of the pole at the ground line by sufficient space to admit the use of a 4-in. tamp bar. It is of the greatest importance that the pole holes should be uniform in shape, and especially is this true if soft ground is being worked. Practically all the holes were "shot," that is, blasted out, for in general the character of the ground worked was either hard pan or hard or soft rock. Bearing these points in mind it is easy to see that the "powder monkey," to be proficient and economical in the use of powder, must be possessed of good judgment and great experience. In fact, it is astonishing to see how expert a "powder monkey" can become. After the hole has been spotted, he knows at a glance the character of ground that he is to shoot out; if it is hard pan or doby he uses a 4-in. auger; if it is hard or soft rock, he uses a drill and hammer, drilling down from 24 to 30 ins. No. 2 Hercules giant powder is used in quantities varying from one-half to two and one-half sticks per hole, according to the character of the ground, and in shooting out a 5-ft. hole in the ordinary ground encountered, the amount of powder used and the position or method of its use is gaged so skillfully that the ground will be loosened to within 2 ins. of the depth desired. Any remaining dirt is barred out, 10 ft., 35-lb. bars being used. Of course, no definite statement of the number of holes a man can shoot in a day can be made for the reason that the character of the ground is altogether too varied to enable any estimate to be formed, but just enough hole diggers are used in a construction crew to keep ahead of the pole setters and wire gang, so that all of the work shall go ahead together. The setting of 40 poles is regarded as a day's work for a crew; that is, a single crew must dig the holes, frame, set and string the wire on 40 poles under ordinary conditions, and this crew will consist of one hole spotter, two "powder monkeys" with sufficient hole diggers behind them to keep clear of the pole crew, eight men in the pole crew, five climbers, two reel men and two men on the blocks.

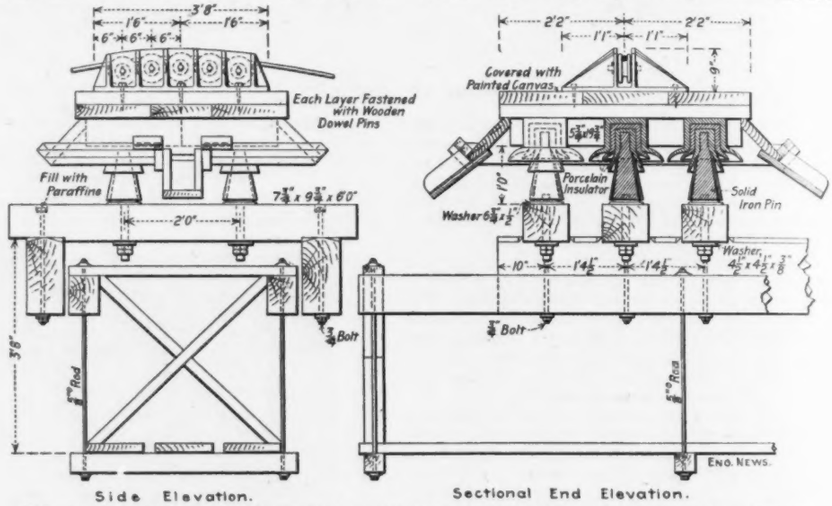

FIG. 21. DETAILS OF SADDLE AND INSULATORS FOR CARRYING CABLES ON TOWERS.

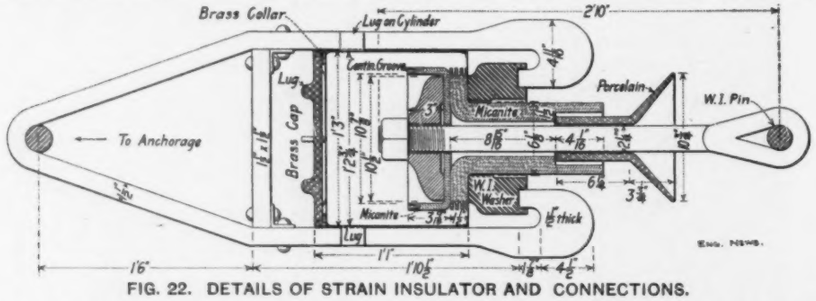

FIG. 22. DETAILS OF STRAIN INSULATOR AND CONNECTIONS.

The main line consists of two pole lines, one of which carries No. 00 B. & S. gage medium hard drawn copper, and the other carries No. 0000 seven-strand aluminum—the equivalent of No. 00 copper. Joints in the copper lines are of the Western Union type with nine wraps on the side and an inch neck, soldered the entire length. Joints in the aluminum line are of the standard form, consisting of a right and left-hand screw conical-shaped joint with the center or core wire of the cable turned back upon itself and the joint filled with solder after being set up tight. No wedge is used, as every function of the wedge is filled by turning back 1½ ins. of the No. 4 core wire. A team of horses on a watch tackle were not able to pull this joint apart.

The copper runs about 1,400 ft. to the coil, two such coils being placed on the reels, when the lines are drawn out by horses. Transpositions are laid out on the ground. All this is being done while the linemen are tying in the last stretch. Then when the linemen get up to where the blocks are, they put on the temporary head guy to hold the line up and the blocks are taken off and sent ahead. Then the line men raise the wire up on the cross arms by the heaving lines which they carry, while in the meantime the same team has gone on ahead and has been hitched on to the blocks. The other line wires are then pulled up together by the team through a set of equalizers on the blocks. The lines are pulled up taut and then dropped back through the equalizers until the proper drop or sag

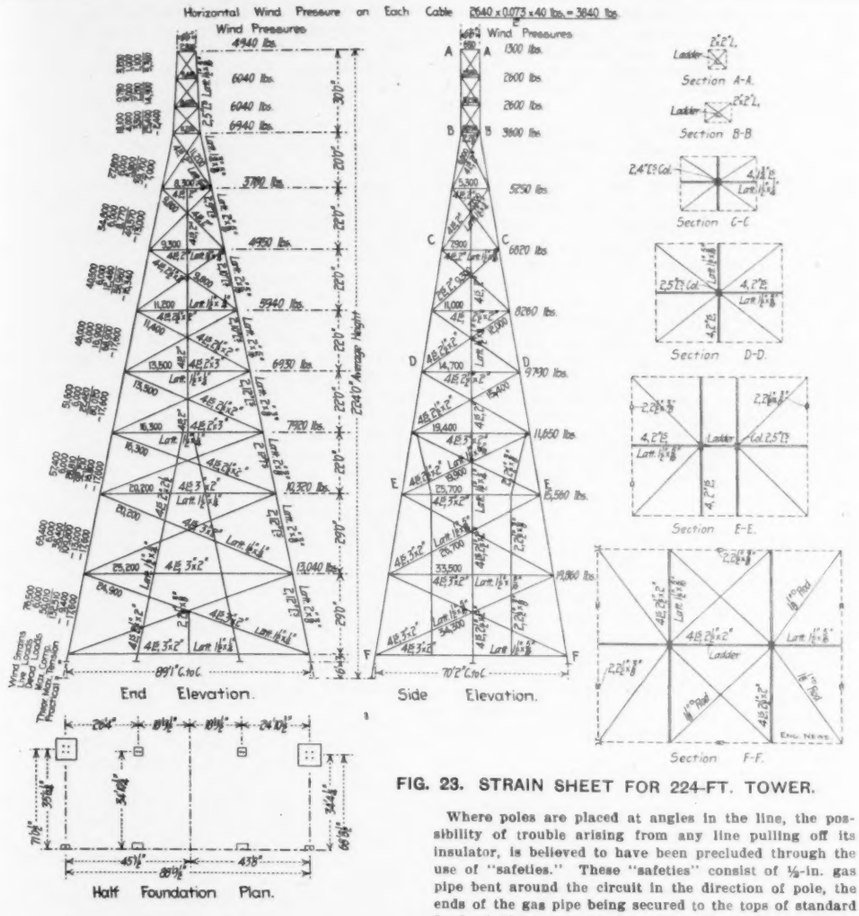

FIG. 23. STRAIN SHEET FOR 224-FT. TOWER.

has been reached—this sag being 18 ins. in the valleys, 22 over the hills, and 6 ins. more around angles than on the straight line. Due allowance from these figures is, of course, made for temperature variations. Head braces are used on all heavy angles to hold the corners, and double construction is used on all road and railroad crossings and angles. No metal is used in head, strain, or anchor guys except with at least 30 ft. of wood insulation intervening between the line wires and the ground. All braces run to cross arms, and it has been demonstrated that while the pole will heave if pole braces are used one-third below the top of the pole, braces will not cause heaving of pole if placed at the cross arm.

Where poles are placed at angles in the line, the possibility of trouble arising from any line pulling off its insulator, is believed to have been precluded through the use of "safeties." These "safeties" consist of ½-in. gas pipe bent around the circuit in the direction of pole, the ends of the gas pipe being secured to the tops of standard Locke high-tension insulators, one of which is mounted on the top of the pole, and the remaining two at the lower end of the safety, being mounted in a special cross arm.

ADJUSTMENT OF TEMPERATURE COMPENSATORS IN PLACING INTERLOCKING SWITCHES AND SIGNALS.

At the recent meeting at Buffalo of the Railway Signaling Club, a paper on the above topic was read by Mr. C. A. Christoferson, Signal Engineer of the Chicago Great Western Ry., in which attention was called to a common error in connecting-up pipe lines for the operation of switches and signals. The author stated that it is the practice of most foremen in putting in interlocking work to make all connections with the crank and compensator arms at right angles to the pipe line (or on the center) when the lever is on the center, regardless of the temperature of the atmosphere. If this is done in a long line of pipe in very hot weather, it will cause the crank or compensator arms to bind against the stand when the temperature falls, making it impossible to latch the lever, and by being thrown too far to one side will also bind and sometimes break the pipe carrier.

To meet this difficulty, Mr. Christoferson furnishes to his foremen a copy of the table herewith reproduced, from which they can at once see whether their line is too long or too short, according to the prevailing temperature at the time, and can connect cranks and compensators at the proper angle. The table was computed on the assumption that a 50-ft. length of pipe line varies 0.04-in. in length for every 10° F. variation in temperature. Inasmuch as a line of pipe exposed to the sun is warmer than the temperature indicated by a thermometer in the shade, foremen are instructed to add 15° to the maximum temperature and 5° to the minimum.

The author also pointed out that cranks less than 9 ins. in length should not be used at all, and on a line of pipe over 200 ft. long cranks longer than 9 ins. should be used.

Table for Connecting Cranks and Compensators in Installing Interlocking Work; Chicago Great Western Ry.
(Figures denote fractions of an inch or inches too long or too short.)

Temperature.	Length of pipe line 100 ft.	150 ft.	200 ft.	250 ft.	300 ft.	350 ft.	400 ft.	450 ft.
Too Long.								
120° F.	5/8	15/16	1 1/4	1 5/8	1 15/16	2 1/4	2 3/16	2 7/16
110° F.	9/16	13/16	1 1/16	1 3/8	1 11/16	1 15/16	2 1/4	2 1/2
100° F.	1/2	3/4	15/16	1 1/16	1 5/16	1 11/16	1 15/16	2 3/16
90° F.	7/16	11/16	15/16	1	1 3/16	1 7/16	1 11/16	1 15/16
80° F.	3/8	9/16	13/16	1 1/16	1 5/16	1 9/16	1 13/16	2 1/16
70° F.	5/16	1/2	11/16	15/16	1 1/16	1 5/16	1 9/16	1 13/16
60° F.	1/4	7/16	5/8	13/16	15/16	1 3/16	1 7/16	1 11/16
50° F.	3/16	5/16	7/16	9/16	11/16	13/16	15/16	1 1/16
40° F.	Center.							
Too Short.								
30° F.	1/16	1/16	1/16	1/16	1/16	1/16	1/16	1/16
20° F.	1/16	1/16	1/16	1/16	1/16	1/16	1/16	1/16
10° F.	1/16	1/16	1/16	1/16	1/16	1/16	1/16	1/16
0° F.	1/16	1/16	1/16	1/16	1/16	1/16	1/16	1/16
10° F.	1/16	1/16	1/16	1/16	1/16	1/16	1/16	1/16
20° F.	1/16	1/16	1/16	1/16	1/16	1/16	1/16	1/16
30° F.	1/16	1/16	1/16	1/16	1/16	1/16	1/16	1/16
40° F.	1/16	1/16	1/16	1/16	1/16	1/16	1/16	1/16

COAL SHAFTS 3,313 FT. DEEP are sunk in the Ronchamp coal fields of France to reach a low-lying coal measure. The plans propose the extraction of 1,000 metric tons per day through two shafts, each 13 ft. in clear diameter. The shafts are surmounted by a metallic structure containing the winding engines, 19.68 ft. in diameter. A steel cable is used, of a total length of 3,844 ft., made in five sections of different diameters, and weighing 14,212 lbs. This cable is rolled up on two conical drums, one behind the other, having diameters of 18 ft. and 35 ft. The cages are in three sections with two mining cars to each section; and the unloading of the cages is automatic. The hoisting engines are of the horizontal, double-tandem type. The air-shaft can be used in an emergency for hoisting, and is fitted with a cage in two sections, attached to a round cable of small dimensions wound up on a cylindrical drum; this is operated by the old machinery used in sinking the shafts. Ventilation is assured by a Rateau ventilator, 11.15 ft. in diameter, providing 2,824 cu. ft. of air. To the plant described must be added automatic safety brakes, various other forms of safety apparatus, and a test department, where regular tests are made of the metallic cables, by tension, torsion and flexure, and of all combustibles; a hospital is also part of the equipment.

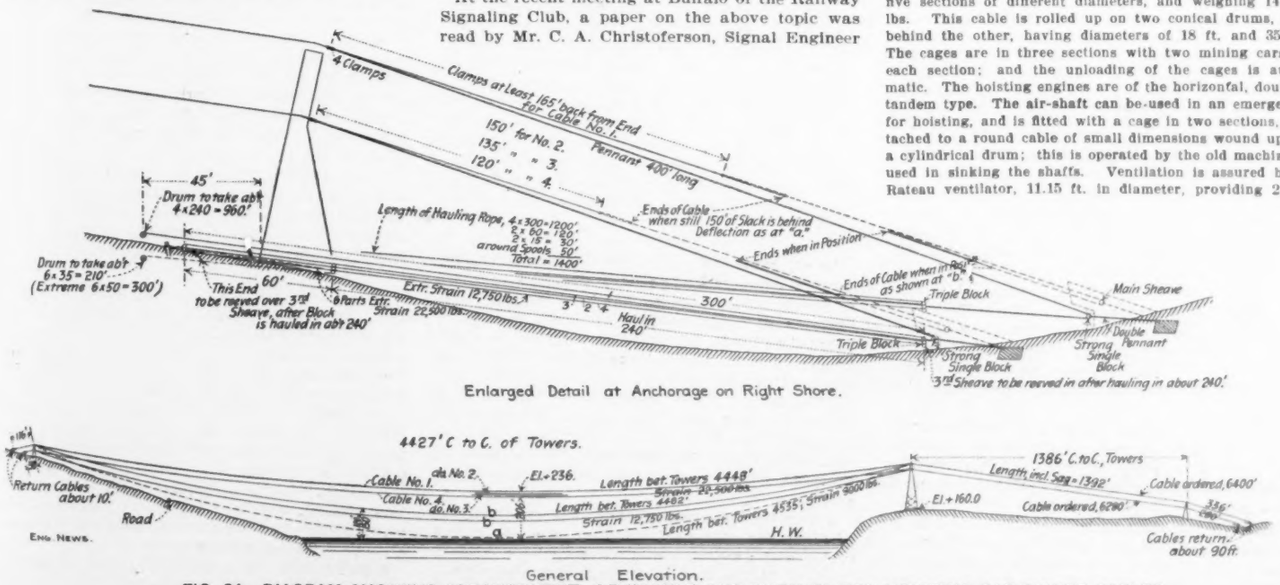
4 Clamps
Clamps at Least 165' back from End
150' for No. 2.
135' " " 3.
120' " " 4.
Pennant 400' long
45'
Drum to take abt 4x240 = 960'
Length of Hauling Rope, 4x300=1200'. 5x60=120'. 2x15=30'. around Spools 50'. Total = 1400'
Ends of Cable when still 150' of Slack is behind Deflection as at "a."
Ends when in Position
Drum to take abt 6x35=210' (Extreme 6x50=300')
This End to be reeved over 3rd Sheave, after Block is hauled in abt 240'
60'
6 Parts Extr. Strain 22,500 lbs.
Extr. Strain 12,750 lbs.
3 2 4
Haul in 240'
300'
Ends of Cable when in Position as shown at "b."
Triple Block
Main Sheave
Triple Block
Strong Single Block
Strong Double Single Block
Pennant
3rd Sheave to be reeved in after hauling in about 240'.
Enlarged Detail at Anchorage on Right Shore.
4427' C to C. of Towers.
Return Cables about 10'.
Road
Cable No. 1.
Cable No. 2.
Cable No. 3.
Cable No. 4.
El.+236.
Length bet. Towers 4448'
Strain 30,500 lbs.
Length bet. Towers 4462'
Strain 12,750 lbs.
Length bet. Towers 4535'; Strain 9000 lbs.
H. W.
1386' C. to C., Towers
Length, incl. Sag = 1392'
El.+160.0
Cable ordered, 6290'
Cable ordered, 6400'
336'
Cables return about 90 ft.
General Elevation.

FIG. 24. DIAGRAM SHOWING ARRANGEMENT OF TACKLE AND SHEAVES FOR HOISTING CAR QUINEZ CABLES.
The Pacific Construction Co., Contractors.

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ADVERTISING RATES: 20 *cents a line. "Want" and "For Sale" notices, special rates, see page XXIV-XXIX. New copy for standing advertisements should be received one week in advance of publication; new advertisements, Monday morning. The pages containing "Want," "For Sale" and "Proposal" advertisements are held open until Wednesday noon.*

Two years and a-half ago, there was described and illustrated in this journal what was then the longest electric power transmission line in the world, that from the San Bernardino mountains to Los Angeles, Cal., a distance of 80 miles. This line was operated at a pressure of 33,000 volts, and the current transmitted was about 4,000 HP.

In the present issue we describe another power transmission plant in California, completed during the present year, which far excels the earlier plant in distance covered and in the pressure and quantity of current transmitted. In this plant current is carried from water-power stations on the upper course of the Yuba River to San Jose, Cal., a total distance of over 184 miles. The pressure used is from 40,000 to 60,000 volts. The current now being delivered at Oakland, 142 miles from the power houses, is about 2,000 K-W., and can be increased as the demand makes necessary, since the company owning the power plant has 17,000 HP. of water power already developed and 13,000 HP. additional that can be used when required.

Such a long step in advance of previous practice, constitutes, we need hardly say, an engineering precedent of great interest. High authorities in electrical engineering have declared that pressures in excess of 25,000 to 30,000 volts were impracticable for commercial work, and it will be obvious that the commercial practicability of electric transmission over great distances depends directly upon the pressure that may be used. For this reason the operation of the Bay Counties transmission at the enormous pressure of 40,000 to 60,000 volts will be watched with great interest.

The paper by Mr. J. D. Galloway in the present issue describes the general features of the Bay Counties company's system, and is particularly complete in its account of the remarkable manner in which the current is carried across the Straits of Carquinez on a suspended span over four-fifths of a mile (4,427 ft.) in length, and hanging at its lowest point over 100 ft. above the masts of the largest ships that pass beneath. So far as we are aware, this is the longest single span of cable ever erected. A wire ropeway with a 4,200-ft. span in the Alps was described in our issue of March 15, 1894, and it was then stated that the builder, Mr. T. H. Carrington, M. Inst. C. E., of the firm of Bullivant & Co., London, contemplated another line with a span of 6,600 ft. We are not aware, however, that this longer line was ever constructed.

The details of the pole and wire construction by which the current is transmitted are covered both by Mr. Galloway's paper, and by two other papers in this issue, read before an engineering society in California a short time ago. In addition to this, we hope in a later issue to present papers describing in detail the design of the generators, transformers and other electrical machinery used in this plant, together with the results obtained and the experience gained in the operation of this remarkable plant.

Meanwhile, we are able to give in this issue a valuable symposium on switches for the control of high-tension currents, consisting of a collection of papers presented at the last meeting of the Pacific Coast Electric Transmission Association. Those who carefully follow these papers and the discussion upon them will probably reach the conclusion that the engineer who adopts high-tension currents for long-distance transmission or other purposes should examine very carefully the apparatus he proposes to adopt for current control.

Popular and spectacular writers on electrical subjects have compared the modern utilization of electricity to Ajax chaining the lightning; but the ordinary low-voltage currents of electricity, such as the public has become familiar with through their use in telegraphy, telephony, bell signaling, and even such lighting currents as are introduced inside houses, has little relation to those static discharges which are the most notable exhibition of electrical effects in nature. When we use currents of such high tension as those whose manipulation is described in this issue, however, we are indeed handling the thunderbolt, and means must be provided adequate to control these enormous forces.

Few engineers have any conception what these currents of 40,000 volts and upward are capable of. Everyone in these days is more or less familiar with electric switches and switchboards, and with the spark that usually accompanies the making or breaking of a contact; but few are aware that at such high potentials as are now in commercial use this spark may become a huge hissing arc, springing five, ten, twenty, or even thirty feet through the air, threatening destruction to everything with which it may come in contact.

In all save the most recent work with high-tension currents it has been assumed that the ordinary switch, such as has been long used for currents of moderate voltage, could readily be adapted to handle high-tension currents, by merely changing its dimensions to give a wider air space. From the discussion published elsewhere, this appears to be far from correct. If a break in the circuit of a current of high tension is made and an arc can form, that arc may blaze about in such wide limits that air space alone cannot be provided under a roof sufficient to care for it safely.

It may be of interest to pause and recollect just what causes this arc. Suppose the two metal surfaces of a switch are in contact with a current flowing. If these surfaces are now separated, resistance to the flow of current is set up at the moment of separation, and this resistance instantly heats the surfaces of the metal, some part of which is vaporized. This metallic vapor, following the path left by the separating terminals in the air, forms a conductor over which the current can flow with much less resistance than through the air. It will be evident that both the volume of the current and the speed of opening and closing the switch have much to do with the liability to arc formation. The greater the volume of current, the more rapidly will heat be generated to vaporize metal from the terminals. The quicker the contact is broken, and the terminals drawn far apart, the less the time available for the arc to form.

Again, the matter of fuses is hardly less important and difficult than the question of switches. With ordinary electrical installations a fuse is simply a small piece of wire so proportioned that if the current which it ought to pass is exceeded the fuse will heat and melt, or more commonly vaporize or "blow." But with high-tension currents, the vaporized metal from a blowing fuse forms an admirable path over which the current can continue to flow. To have such fuses exposed in the open air, as in ordinary direct-current work, is, therefore, out of the question. If either fuses or switches are to be used on excessively high voltage circuits, some means must be provided by which the arc will be extinguished. Two methods appear to be in use for this, each of which has been fairly successful. In one the contact between the conducting parts is broken in a bath of insulating oil. This immediately rushes in to fill the space between the terminals when separated, and its insulating strength being so much greater than that of air, the arc has no chance to form. In the other, the contact between the parts is broken inside a tube made of incombustible material and filled with an infusible powder. This powder falls between the terminals as they separate and extinguishes the arc.

The troubles with high-tension currents do not end with the formation of long and dangerous arcs when the circuit is broken. According to the testimony of the Pacific Coast engineers who have large experience in this work, the making and breaking of these high-tension circuits when current is flowing puts the insulation of transformers and other apparatus under a serious strain. We can compare it, perhaps, to the water hammer set up in a pipe when a valve is suddenly opened or closed, and just as repeated water-hammer may weaken and finally burst a pipe, so repeated use of high-tension switches, according to some engineers, is sure to lead to breakdown of the insulation.

Nevertheless, it must be conceded that in any plant of considerable size, switches are a necessity; and while making or breaking a circuit carrying forty or fifty thousand volts will naturally be avoided whenever possible, at times it must be done to maintain continuous service to customers and permit the economical operation of the plant. In the Bay Counties Company's system, for example, three different power houses are so connected that current can be taken from any one of them for the supply of the score or more of places to which current is carried. Switches on any such system are a manifest necessity. That the difficulties in handling such switches are not insurmountable, the successful operation of the Bay Counties system appears to prove.

Apropos of our comment last week on the recent fatal railway collisions in Montana and in Austria, and the need of better and more systematic attention to the maintenance of brakes, we would call attention to the paper read last week before the New York Railroad Club, by Mr. F. M. Nellis. The title of the paper is "Brakes in Railroad and Street Car Service;" and it comes near being a treatise upon that subject, as it covers nearly 44 pages of the club's "Transactions." Its length, of course, precludes its reprinting in this journal; but we advise our readers in any way interested in the subject to secure if possible a copy of the complete paper.*

A fact which Mr. Nellis makes clear is that the necessity for careful maintenance of the air brake is a direct outcome of the high speeds and long and heavy trains which have become such a prominent feature of modern railway service. A

*Applications for copies should be addressed to Mr. W. B. Yereance, Secretary New York Railroad Club, 168 Montague St., Brooklyn.

CK AT LOWER END OF COLGATE FLUME.

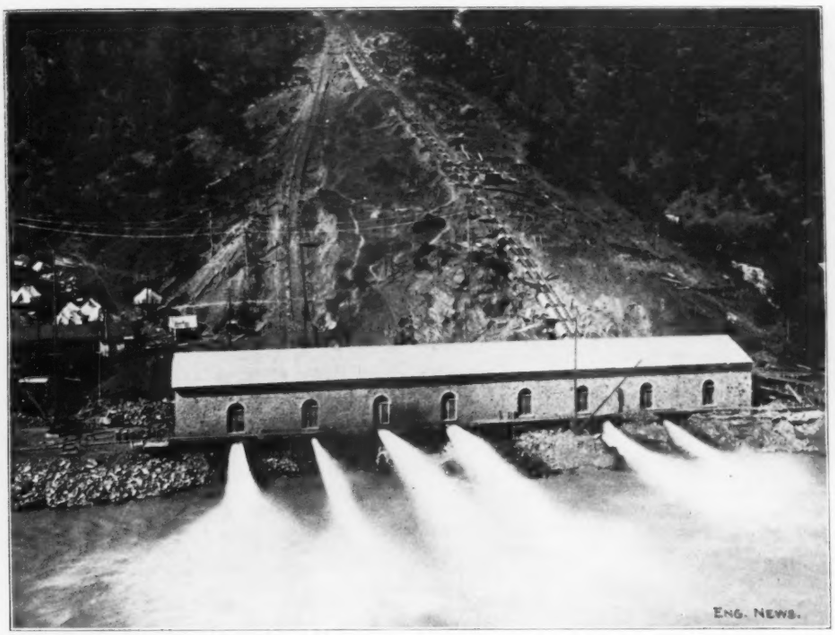


FIG. 5. VIEW OF COLGATE POWER-STATION AND PIPE LINE.

OF CABLE CROSSING AT STRAITS OF CARQUINEZ; 4,427-FT. SPAN.

FIG. 11. SOUTH SIDE TOWER; CARQUINEZ CROSSING.

FIG. 14. PART OF LEANING TOWER, TRANSFORMER STATION, ANCHORAGE HOUSES AND POLE LINE; CARQUINEZ CROSSING.

FIG. 12. CABLE OILER IN HIS CARRIAGE.

WATER-POWER AND ELECTRIC TRANSMISSION SYSTEM OF THE BAY COUNTIES POWER CO., CALIFORNIA.

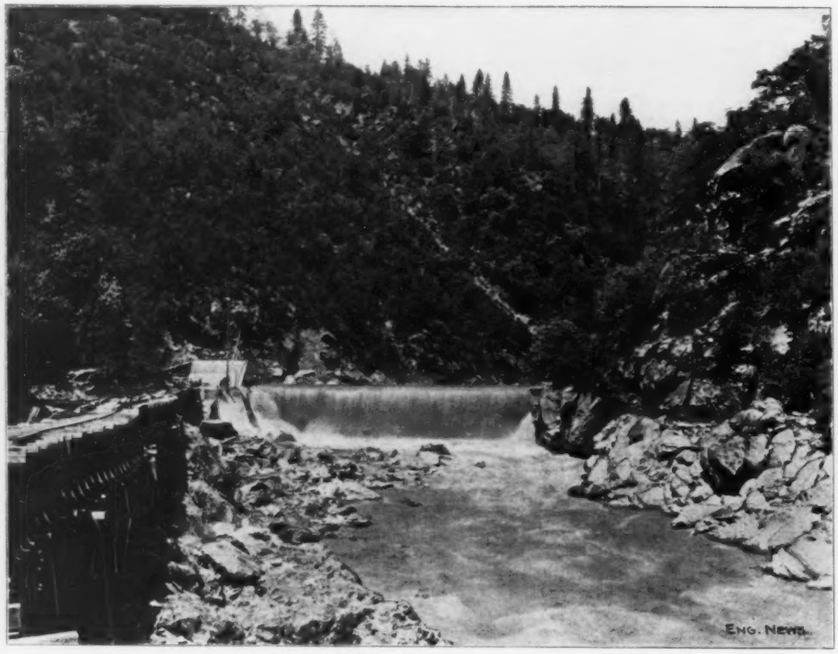


FIG. 2. DAM AND HEAD GATES OF COLGATE FLUME.

FIG. 4. PENSTOCK AT LOWER END

FIG. 8. GENERAL VIEW OF CABLE CROSSIN

FIG. 3. A PIECE OF DIFFICULT CONSTRUCTION ON COLGATE FLUME.

FIG. 10. LEANING TOWER; CARQUINEZ CROSSING.

FIG. 14. PAR
TRANSFORMER ST
AN
CARQU

dozen years ago railway officers paid little attention to the air brakes on their rolling stock, and there was on many roads no system at all for the inspection and repair of brakes or for the instruction of employees in their use. Mr. Nellis says that no longer than ten years ago there were only three railway companies in the United States which had a general air-brake inspector, clothed with full responsibility for the care of all air brakes in the company's service. To-day more than half the railways have such an official, and there is a flourishing association with a membership of over 700, composed of these officers and others connected with air-brake manufacture and repair.

The triple-valve is the nerve-center of the air-brake apparatus, and with short trains the impulses which cause it to act are such that it will usually operate even though it be badly worn or clogged with dirt. On long trains, however, the wave of pressure through the train pipe loses its force in ordinary applications, so that much trouble is being experienced of late with the brakes near the rear end of long trains refusing to release or failing to apply. So serious is this condition that not a few railways prefer to use the air brakes on only part of the cars of a long train, believing that they are more certain of safe and efficient braking than if they attempt to operate the brakes on all the cars. As Mr. Nellis clearly shows in his paper, this trouble is due to worn and insensitive triple-valves. Many of these valves have now been in service for ten years and more, and the renewal of worn parts has become a necessity. These repairs cost but little, but they must be done in a proper manner or the last state of the triple-valve will be worse than the first. The air-brake manufacturers have now established a special department for the repair and renewal of the parts of worn triples, and by the use of special machinery and operation on large quantities are able to do the work at much less cost than the railways themselves.

The proper maintenance of brakes is a matter which concerns the railways as a whole. The company which neglects its air-brake equipment and allows its cars to go about the country with brakes in bad condition causes trouble and expense and danger on all other railways where its rolling stock may go. The great advance in economic railway operation which the past 20 years has seen is due, more than anything else, to the increase in the length of trains and the size of train loads. But in order to handle such long trains with safety and economy, the air brake is absolutely essential; and in order that the air brake shall be a safety apparatus, and not something liable to fail when an emergency comes, it must be properly maintained. It may seem a trifling matter if the brakes near the end of a long freight train should fail to release with the others; but just such sticking of brakes may and frequently does cause the train to break in two, and the disastrous results that may follow a break-in-two are well illustrated by the fatal accident in Montana. On the other hand, suppose it is only a single car or two whose brakes stick on, when the others release, and the conditions of grade are such that the train runs on a long distance with these brakes applied. The result may be a wheel so hot that it will fail at some frog or switch, and pile the train behind it in a wreck. These are only samples of the reasons why American railways cannot afford to be in any way negligent in the maintenance of brakes, and why any railway company which is negligent in this matter ought in some way to be put under pressure to do what is so manifestly for its own interest, as well as its neighbors'.

AN IMPORTANT PROPOSAL TO AN ENGINEERING SOCIETY.

The American Society of Mechanical Engineers, if a pending amendment to its constitution is approved at the coming annual meeting, will hereafter charge its members the highest annual dues of any engineering society in the world, viz., $25 per year for Members and $15 for Juniors.

It may be of interest to see how these dues compare with those of other societies: The annual dues of the American Society of Civil Engineers are $15 for Members and Associate Members, and $10 for Associates and Juniors. For resident members (those residing within 50 miles of New York) an additional fee of $10 per year is charged the first class, and $5 per year to the second class This is on account of the supposed greater benefit which resident members obtain from their use of the society's house. The number of resident members, however, is barely a quarter of those on the society's rolls. The American Institute of Electrical Engineers has only two grades of membership, Member and Associate; the dues are alike for each, $10 per year, which is reduced to $5, however, for members residing in foreign countries. The initiation fee in this society is only $5, whereas in the American Society of Mechanical Engineers it is $25 for Members and $15 for Juniors. The American Institute of Mining Engineers has dues of $10 per year for all its members alike. The Society of Naval Engineers and Marine Architects has dues of $5 for Members and Associates and $3 for Juniors.

When we go from the engineering societies of national scope to those of local extent only, the dues are found to be much smaller, except when, as is sometimes the case, the society combines the functions of a social club with that of a professional society. Even in this case, however, the dues are generally moderate. Taking as a random example, the Boston Society of Civil Engineers, we find its members pay annual dues of $8 per year, which is reduced to $5 if they reside more than 30 miles from Boston.

It may be of interest to briefly note also the dues of some foreign engineering societies. In the Canadian Society of Civil Engineers the dues are for Members $10, and Associate Members $8, reduced by $2 in each case if the residence is more than 50 miles from Montreal. Students pay only $2, whether resident or non-resident. In England the Institution of Civil Engineers, with the greatest fame and prestige of any engineering society in the world, charges $15 to Members, $12.50 to Associate Members and Associates, and $7.50 to Students. Members residing within 10 miles of the London Post Office pay $5 additional, and all other grades $2.50 additional. In the Institution of Mechanical Engineers, Members pay $15, Associate Members, $12.50, and "Graduates," as the lowest grade is designated in this society, $7.50.

It will be seen from the above brief review that after the proposed increase, the annual dues in the American Society of Mechanical Engineers will be, as stated above, far in excess of those of any similar engineering society in the world.

We imagine that some member of the Society's Council (which has recommended the raising of the dues) may object that the dues fixed in other societies have nothing to do with the case; and that the society should regulate its own affairs regardless of the policy other societies may adopt. But we have an excellent precedent for making the above comparison.

When the American Society of Mechanical Engieers was founded, its dues were $10 for Members and $5 for Juniors. Ten years ago these dues were raised $5 in each grade. Prior to the annual meeting in 1891, at which a vote on the proposed increase was taken, the Council of the Society sent a circular to each member stating in detail the reasons why an increase in dues was recommended. We quote from this circular as follows:

> Except some European societies having a different social membership from our own, no engineering society has lower dues. The English professional societies have dues of $15 and $25, and give a return no greater, or in some cases less.

In view of the above exhibit, which covers most of the leading engineering societies of this country and England, it is difficult to see on what grounds the above statement was based.

The fact is that the dues in the Mechanical Engineers are now and have been for ten years higher on the whole than those of any other professional engineering society in the world except the Institution of Civil Engineers and the American Society of Civil Engineers. Except for the additional charge to "resident" members in these societies, the Mechanical Engineers' dues are quite as high as either of these.

The natural question, of course, is why it is proposed to make this large increase in the annual dues; and to this question no official answer is yet forthcoming. In fact, there has been no notice given to the membership of the society at large that an increase in the dues is proposed. It is true that a formal notice of the proposed increase in the form of an amendment to the society's "Rules" was read at the Milwaukee meeting last summer; but this notice reached, it is probable, not more than a sixth or eighth part of the total membership. Except as members not present at Milwaukee may have been informed through the technical journals, they are still in ignorance of the fact that unless the Council's plan is voted down at the December meeting of the society they will have to either pay $10 additional per annum to the society, or forfeit their membership.

Notwithstanding the lack of official explanation however, current rumor enables one to explain pretty well the reason which will be assigned for the increase of dues when the Council sees fit to enlighten the membership. The fact is that the society's house in New York city has become too small as a place for holding the annual meeting of the society, and it is proposed to build a new and larger house and to raise the money for that purpose by a general tax on the society's membership in the form of increased dues.

In our issue of Jan. 17 last, we called attention to the inadequacy of the society's house to accommodate the annual meeting, and urged that instead of proceeding to multiply costly engineering headquarters in New York city, some arrangement be made for the joint use of the new building of the American Society of Civil Engineers by all the national engineering societies. Our esteemed contemporary, "The American Machinist," has recently discussed this question editorially in so sensible and candid a manner that we have reprinted the article in full on another page of this issue.

Additional pertinency is given to the proposal for a joint engineering headquarters in New York city by the fact that the Institute of Electrical Engineers is likely also soon to agitate the question of a permanent headquarters. The Institute has recently received from Mr. Schuyler S. Wheeler a gift of the Latimer Clark library, a rare and valuable collection of works on electricity. One of the conditions of the deed of gift is that the Institute shall within five years provide itself with a permanent home for its meetings and library.

As we pointed out last January, and as our contemporary well shows in its editorial elsewhere reprinted, engineering society buildings in New York are at present a remarkable example of the wasteful use (or absence of use) of valuable property. The Mechanical Engineers' house, for example, furnishes an office headquarters for the society's employees, and contains its library; but its auditorium and refectory, which occupy most of the space in any properly-designed society building are used by the society on just four days in a whole year.

There is no reason whatever (unless it be possible petty jealousies between the governing bodies of the several societies) why the public audience rooms of the American Society of Civil Engineers' house should not be leased to and utilized by every engineering society which holds meetings in New York city. Indeed, one such organization, the New York Railroad Club, has already begun holding its meetings there. Further, we believe it would be practicable to add to that building in such a manner as to accommodate the office force of both the Mechanical Engineers and the Electrical Engineers, with the libraries of both societies. Such an engineering center would be far more attractive than the headquarters of any one society at present can be.

In the flourishing Engineers' Club of New York, civil, mechanical, electrical and mining engineers all meet in harmony, with never a thought of rivalry or jealousy. Why on earth should such unworthy sentiments prevail any more if these same men were to meet in a house for the joint use of professional societies?

The fact is that jealousy between the different societies is too childish to be worth talking about.

accuracy), endeavor to convey the general idea of what for all practical purposes appears to happen.

THE COOLING OF STEEL.

MOLTEN TO CRITICAL POINT.—When molten steel cools it crystalizes, the pure iron "grains" settling out, and the more quietly and slowly it cools the larger they are. The last part to set contains more of the carbon and impurities, and may be termed the "cement" which binds the grains together.

If disturbed just as the grains are formed, this cement is still so liquid or soft that they have little or no cohesion, and the material is quite "rotten" or red-short in the extreme.* At a little lower temperature it becomes cohesive and freely plastic, and it can therefore be readily worked, the cement being so soft that the grains, though cohering enough to permit this, are not held rigidly in their relative positions, but are able to move about each other so easily that they are not themselves appreciably broken up; and if work is stopped whilst at this temperature, especially if the cooling is slow, the grain is found to be very large and coarse. In fact, at this temperature the size and shape of the grain is not affected by work, only by the interference and other conditions of cooling, and the piece exhibits no flow lines and has no rolling hardness. The larger the grain, however, the less coherent it is (owing to the larger area of the cleavage planes) if subjected to sudden shock; so the piece is wanting in toughness, and may be actually "rotten."

more they are "broken up" in working, and the more power it takes to make them flow, the lines of flow becoming more clearly defined, and the mass in parts, being already stretched or under tension by the unequal strains set up by the distortion of working, is harder or stiffer.

The higher the temperature below the critical point described, at which work on the piece is finished, not only are the strains set up by working less in the first place, but the longer time it will take to cool, and whether from this or from its large mass, or any other cause, if its cooling is retarded the strains set up gradually distribute themselves, and are correspondingly diminished or eliminated, and the final "rolling hardness" is therefore less. If the finishing temperature is lower, this softening effect is, of course, less. Thus to a certain point the hotter the finishing temperature the softer the material, though not necessarily tougher, for if the grain is too large there will be want of toughness. The ideal finishing point is clearly, therefore, that at which these two opposite tendencies are properly balanced.

BELOW RED HEAT.—As work is continued, the relative plasticity of the cementing material to that of the grains becomes rapidly less, until it reaches at blue heat, the state of minimum plasticity, approximately 316°-371° C. The grains adhere so strongly that if force is applied to change the shape of the material (whether by work or by the effects of violent expansion or contraction through sudden or local chilling), it does not uniformly

still lower temperatures—say, below freezing point—it becomes harder again.

From the foregoing we see that toughness depends on cohesion of the grain, and the greater this is the greater the toughness. Want of cohesion at or near the setting point, or at any temperature down to red heat, is termed "red-shortness." Want of cohesion when cold (atmospheric temperature) is "cold-shortness." Softness is readiness of the grain to change its relative position, and hardness the reverse.

The behavior of steel at different temperatures would seem to suggest the occurrence of the changes in the "grain" and "cement" whilst cooling, indicated by the diagram Fig. 1.

This diagram is not intended as a measure of the changes, but simply to indicate their directions.

Chilling at low temperatures does not harden steel if work has not been continued to these low temperatures, but if it has, then chilling fixes the hardness.

REHEATING.

When material which has been worked below critical temperature, and hence is distorted and strained, is reheated, as the temperature rises the reverse effects take place to a large extent, provided there is no external work. After passing above blue heat the grains and the cement holding them together get softer, and begin to yield to the internal strains till they adjust themselves, and so, although the mass retains its new shape, its internal struc-

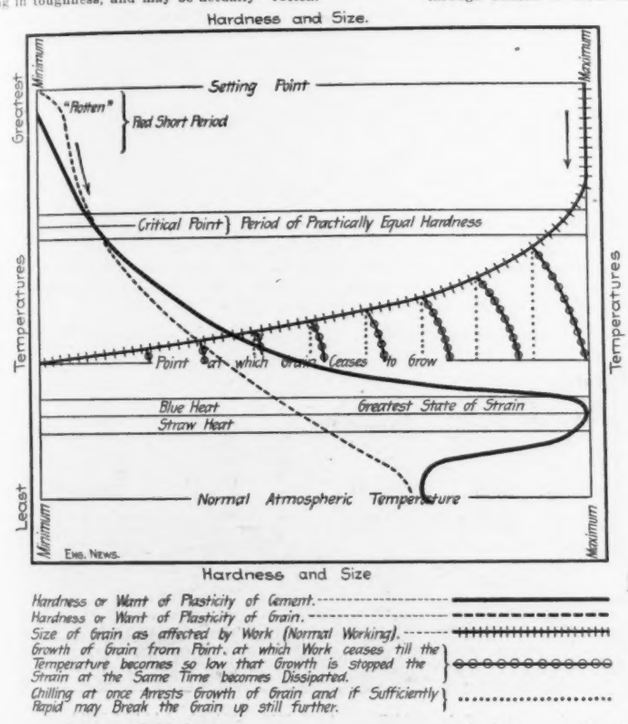

Hardness and Size.
Greatest
Minimum
Maximum
Setting Point
"Rotten"
Red Short Period
Critical Point
Period of Practically Equal Hardness
Temperatures
Point at which Grain Ceases to Grow
Blue Heat
Straw Heat
Greatest State of Strain
Normal Atmospheric Temperature
Least
Eng. News.
Hardness and Size
Hardness or Want of Plasticity of Cement.
Hardness or Want of Plasticity of Grain.
Size of Grain as affected by Work (Normal Working).
Growth of Grain from Point at which Work ceases till the Temperature becomes so low that Growth is stopped the Strain at the Same Time becomes Dissipated.
Chilling at once Arrests Growth of Grain and if Sufficiently Rapid may Break the Grain up still further.

FIG. 1. DIAGRAM SHOWING CHANGES IN THE "GRAIN" AND "CEMENT" OF STEEL WHILE COOLING.

For clearness, the last two lines of the legend attached to the engraving have not been carried beyond the line indicating the point at which grain ceases to grow. From this they would, of course, continue parallel with the maximum and minimum lines to the line indicating normal atmospheric temperature.

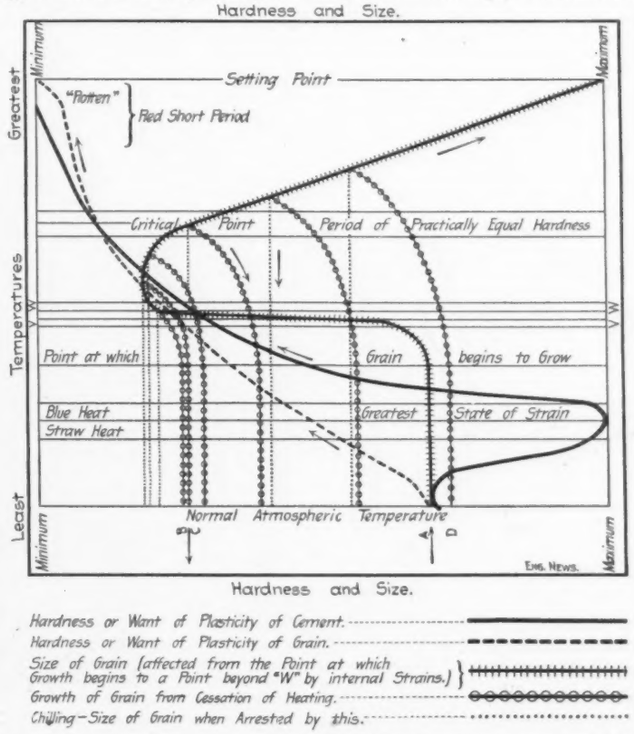


FIG. 2. DIAGRAM SHOWING CHANGES IN THE "GRAIN" AND "CEMENT" OF STEEL WHILE REHEATING.

The size of grain at commencement of reheating is shown at A; Reheating only to W gives the finest grain obtainable with slow cooling as shown at B; Reheating a little (say, 100° C.) above W, by allowing more regrowth, gives a slightly larger grain as shown at C; If reheated to a sufficiently high temperature, the grain has grown again so much as to be larger than before reheating as shown at D.

CRITICAL POINT.—The point of equal hardness of grain and cement, at or below which change of shape of the mass (by work) begins to affect appreciably the size and shape of the grain. As the temperature descends a point is reached at which the cement is approximately no softer than the grains, so they will not so readily move about or flow in it; and when the work applied is sufficiently strong, all yields together, and the grain is broken up or elongated, kneaded and interlocked, and the material thus becomes tougher, being dovetailed as well as stuck together. Flow lines become distinct, and rolling hardness begins to be imparted, these effects being less marked if the cooling is very slow.

This has been termed the "critical point," and is probably for soft steel about 1,000° C., say, orange or bright red, and lower for higher carbon steel. Below this point to low red the grain becomes finer and more interlocked, and hence to a certain point the lower the temperature to which it is continued the more work increases toughness of material. At the same time as the temperature decreases the stiffer the binding medium becomes, and the more strongly the grains adhere, and consequently the penetrate the mass; internal strains, more or less nearly equal to the extent of its endurance, and which may be termed incipient rupture, are set up, and actual rupture between or in many of the grains frequently occurs, those nearest the surface being sometimes partially detached or loosened. Thus, although strain applied slowly will often, by forcing parts to stretch which had not previously done so to the full extent of their elastic limit, afford relief and allow the material to bend without rupture, there is always a predisposition for the mass to break under sudden stress or vibration. The temperature, too, from which the piece has to cool is so low that there is little or no opportunity for these strains to be distributed and thus relieved. Chilling, of course, in all cases accentuates the strains or rolling hardness, but in the case of a piece of steel chilled from near critical point the initial strains set up by work have been so slight that, though chilling fixes them, the total hardening effect is for soft steel far less than in the case of steel first worked down to a much lower temperature, even if slowly cooled afterwards.

BELOW BLUE HEAT.—After the temperature of working gets below straw heat (250° C.), and until it is really cold—i e., at atmospheric temperatures, say 15° C.—steel is more plastic than at a blue heat, though still affected in much the same way if work is sufficiently strong. At

ture is rearranged, and the strains redistributed or removed, and the material loses its rolling hardness and becomes soft and tough again. This is true annealing.

However, just as the cement in cooling below red heat became harder than the grains, so in reheating correspondingly; at these temperatures the grains are still softer, and hence if the heating is rapid the grains soften more quickly than the cement, and it is they which yield to the internal strains (already existing and also set up by rapid heating) and become pulled asunder, or out of their more or less regular shape into new and more interlocking shapes, and are thus "broken up." This even applies to the large grains of material finished too hot, and is particularly important because material predisposed to be brittle from either being finished at too high or too low temperatures regains its good qualities if rapidly reheated. If the heating is more gradual, the strains operate less violently, and, though the softening effects are to some extent obtained, the "breaking up" is less marked. Hence the importance of the heating being rapid to obtain the maximum softening effect.

When the temperature rises above critical point again, the cement becoming softer than the grains, they follow the natural law of attraction and tend to aggregate into larger grains with thicker intervening bands of cement, just the same as before the material had received suffi-

*Notice how easily, for a second or so after they are made, splashes of steel can be broken up by a bar, but immediately afterwards it becomes very tough and difficult to tear apart.

If the question were fairly submitted to the members of the American Society of Civil Engineers whether they desired their house in New York to be made a joint headquarters for the chief national engineering societies, we have not the slightest doubt that the vote would be overwhelmingly in its favor. Yet the story goes that tentative proposals for such a joint headquarters were unceremoniously turned down by the Board of Direction of that society a few years ago.

Even if surviving prejudices on the part of the governing bodies of the societies should prevent such co-operation as we have outlined, it would be in the highest degree unwise for the Mechanical Engineers to adopt the proposed increase of dues. Already the dues, we know, are such as to shut out from membership many able engineers, and with the dues raised to $25 per annum this would be much more the case. It is not difficult to find already in the society's membership two classes of members. To one class, holding high executive positions, and in many cases owning large interests in industrial enterprises, the proposed increase of dues is immaterial. To the other class, who are doing the real practical professional work, in the field, the shop and the office, the proposed increase of dues is a serious matter. Many such men will, we doubt not, feel obliged to give up their society membership in case the dues are raised as proposed; and the future accessions to membership of just the class of men which the society most needs will be greatly reduced.

It cannot be successfully urged, either, that the proposed increase of dues is a necessity. Ten years ago, with a membership of about 1,200, the annual expenses of the society were less than $18,000. In 1900, the society had a net income of $42,500 in round numbers, but all but $1,800 of this was swallowed up by the society's running expenses. In matters of this sort plain speaking is best. The fact is that no other American engineering society spends anything like such a sum annually except the American Society of Civil Engineers; and the members of that society, by the volume and character of its publications and the number of its meetings, receive a much larger return for their dues than do the members of the Mechanical Engineers.

The present Mechanical Engineers' house is sufficient for every present need of the society save only the gatherings during the one week of the year when the annual meeting is held. But for that one week it is perfectly feasible to lease a suitable auditorium at a moderate rental. To erect a costly building for that alone would be to heap folly on absurdity.

If is finally deemed best to establish a new and larger quarters, either independently or in co-operation with other societies, the present income of the society should be administered with such economy that no further tax on the membership of the society as a whole will be necessary.

LETTERS TO THE EDITOR.

Standard of Measurement for Land Surveys in Pittsburg, Pennsylvania.

Sir: I note in the last issue of Engineering News an article on "Standards of Measurements in Field Engineering," by Benj. Franklin, C. E. In it he mentions the difference between the United States standard and the local standard of certain cities, but I do not see that of Pittsburg, Pa., in the list. I will say that we in the "Smoky City" are also as unfortunate as New York, Brooklyn and Boston in not having a universal standard of measurement.

Our so-called "city standard" is variously estimated as .08, .09 and .10 of a foot longer than 100 ft. U. S. measure. The standard of measure is laid off on the marble tile on the fifth floor of the City Hall, and is 25 ft. long, being the length of the original wooden rod used in early days in laying out the city of Pittsburg. This rod was in some way made about a quarter of an inch too long; hence the error, which is perpetuated by the engineering department of the present time.

It is certainly unfortunate that we have not a standard here, as in "regulating" or pinning off a lot in an old plan, where there are no monuments, we are sometimes at a loss to know what measure to apply, unless we look up the engineer who laid out the plan, as sometimes "U. S." has been used and sometimes "city." The custom, of course, if monuments exist, is to measure up between two stones or original pins and establish the measure, which I am forced to say in some old plans is neither "U. S." or "city!"

The 50-ft. tape, owing to our hills, is almost universally used here. To take out the sag in the tape, a pull of 10 or 12 lbs. is exerted. Yours respectfully,

A. E. Duckham, C. E.

No. 431 4th Ave., Pittsburg, Pa., Sept. 26, 1901.

The Design of a Four-Track Two-Truss Draw-Span.

Sir: In the article on a "Four-Track Swing Bridge for the Chicago & Western Indiana R. R.," published in your issue of Sept. 12, the author has made an oversight in his inference that by putting two tracks on cantilevers the span is decreased about 20 ft. for the same waterway as compared with the four-track New York Central bridge over the Harlem River having three trusses. As his bridge measures about 57 ft. in width outside of guard timbers, it is difficult to see how he can gain more than about 18 ins. on each side, assuming the N. Y. Central pier at 60 ft., as stated. Moreover, this is accomplished by sacrificing the pile fenders, an expedient of very doubtful value since a vessel striking the guard would be liable to smash the cantilever brackets, especially as they are not braced together by diagonal members, or it might move the bridge bodily to one side. It may also be stated that the use of square rods for the upper chord bracing does not seem in keeping with the solid character of the bridge. Stiff diagonals made up of four angles latticed would conform better to modern practice. Another feature which is rarely found at present in similar cases is the eyebar hangers with short bottom posts for floor-beam attachments. The use of four different widths of eyebars where two would have answered seems an unnecessary hardship for the shop. The diagram of turntable is drawn on so small a scale that it cannot be clearly made out just in what proportion the three points at each corner share the load. The truss seems to strike the loading beam too close to the drum. With a load on one cantilever and the adjoining inside track and the other tracks clear, there will be an uneven load on the drum tending to warp it, no matter how well the distribution may be arranged for full loading on all four tracks. The use of three trusses undoubtedly affords an opportunity for a more uniform distribution of live load over the drum.

Yours truly, Henry Szlapka.

Pencoyd, Pa., Sept. 17, 1901.

In accordance with our usual custom we referred the above criticism to Mr. W. M. Hughes, the designer of the bridge in question, who has replied as follows:

Sir: Referring to the above criticism of Mr. Szlapka relative to the design of the four-track swing-bridge for the Chicago & Western Indiana Ry. Co., crossing the Drainage Canal, the clear waterway referred to was not for navigable purposes. It is clear that if 20 ft. is added to the diamefer of the center pier, the span must be 20 ft. longer in order to obtain the same capacity as a waterway. As the protection will be open piling this will not materially decrease the capacity for this purpose. As to the use of square rods for the top lateral bracing, they certainly answer the purpose for which they are intended; then why put in the additional material that stiff bracing would require?

It must be admitted that with the heavy sections required in this bridge, the eyebar hangers are the more economical. If there is any serious objection to their use the author of the criticism fails to state what it is.

The load is distributed on 12 equi-distant points of the drum, two-thirds passing through the chord beams and one-third through the short girder between the chord beam and the drum, the center of the bracing being one-third of the distance from the chord beam to the drum.

If Mr. Szlapka will take the trouble to analyze carefully the effect of the unequal loading on the drum due to a load on the outside with no live load on the other tracks, he will find there is practically no tendency to warp the drum; at least no more than there would be in a three-truss design. Possibly this might be the case with a much lighter structure.

W. M. Hughes, M. Am. Soc. C. E.

1511 Great Northern Bldg., Chicago Ill., Sept. 25, 1901.

Concerning Notable Errors in a Recent Popular Engineering Publication.

Sir: Some time ago, when a number of letters relating to the advantages of correspondence schools and engineering colleges appeared in your journal, it was in the writer's mind to beg permission to point out that the most desirable qualification in an assistant is a growing tendency to do accurate work and to restrict his statements to facts that are well authenticated. Whatever training—whether in or out of college—operates to bring about this condition or result, either in a student or in one engaged in active work, is greatly to be desired.

This commonplace matter was brought again to my attention when perusing in "Cassier's Magazine" for August a paper upon "Utilizing the Sun's Energy." This paper was written by a well-known and gifted author; yet it contains the remarkable statement that [illegible] available energy of the annual rainfall upon one square mile, with a height of fall of 10 ft., would develop ten [illegible] horse-power for ten hours a day and three hundred [illegible] in the year!

This, with other similar statements in the paper, might at this time, when so much attention is given to the development of water power, awaken some needless hopes and even lead, on account of the author's reputation, to surveys and to unwise expenditures of capital.

There are, however, in the nature of the case some safeguards. The talented author is surrounded by pretty bright young men from various parts of the country, and it would be a little strange if some one among them had not already interested himself in the economical use, under a low head, of the rainfall upon a thousand acres, more or less, of New York territory. If so, and if he has used the few horse-power obtainable, for lathe or similar work, he has doubtless opened and closed head gates in the rainy season without the least suspicion that he was controlling forces that would drive at full speed all of the navies of the world! Or a farmer lad student, with recent harvest-day notions of the amount of work performed by one horse, might perceive that it would be impossible to assemble ten million horses upon one square mile; and that even if this could be accomplished and the horses were well fed, each one might be expected to develop in the course of a year considerably more than enough energy to raise to the height of 10 ft. all of the water and snow that fell upon his own back!

It is hardly worth while to follow the author into the West, where he locates Des Moines on the Mississippi and attributes to the "Father of Waters" enough energy to divert our planet from its natural orbit. The sad thing about it all is that anyone in the discussion of an important subject should permit himself to use words without regard to the ideas that those words convey. This offense is closely related to the "unpardonable sin," even when the offender is untrained; and if he has had the advantages of a correspondence school or a great university, the relationship is not more distant. M. Am. Soc. C. E.

Chicago, Ill., Aug. 20, 1901.

(We quote verbatim as follows from the article in "Cassier's Magazine," which our correspondent very properly criticises:

The mean annual rainfall of the world is 36 ins. a year, and this means about 50,000,000 cu. ft. per square mile per annum falling on the land of both hemispheres. Taking the mean available height of fall as 10 ft., and assuming it possible to store the water effectively in ample reservoirs, this would mean 500,000,000 × 60 = 30,000,000,000 ft. lbs. of available energy, and if expended in 3,000 working hours it would give a total of 10,000,000 HP. per square mile for such countries as might be able to utilize such a fall. This, however, is but a small fraction of the inhabited area of the globe. As a fair estimate, the data for the Mississippi River, in the United States, may be taken. This stream drains about 1,250,000 square miles, with a rainfall of 30 ins., an average for each foot of fall of 11,000,000,000,000 ft. lbs. per annum. The fall is 6 ins. per mile, average, and the energy capable of use for that area is about a quarter of a million horse-power per square mile.

Proof of the above letter was submitted to the author of the paper in "Cassier's Magazine," and his reply is appended.—Ed.)

Sir. The response to this unique communication may be made very brief. The writer never had the slightest intention of making such extravagant assertions. Had he so intended, the proper course would now be, not an ill-considered attack upon him in a leading and widely circulated technical journal, but the appointment of a commission of expert alienists to decide a question of sanity.

The Des Moines rapids, not the city of Des Moines, was the locality referred to; the large numerical values quoted, as any careful reader would discover from the context, are foot-pounds per hour, not horse-power as the ellipsis makes the text read. To correct the misprint, for horse-power read foot-pounds. Or, otherwise, insert foot-pounds per hour and the equivalent figure for horse-power.

Notes and Queries.

We have lately received a sample from a deposit of pure white sand which has recently been discovered in Pennsylvania. The sand is so white that it exactly resembles salt or powdered sugar. It should be valuable for making mortar for use with white marble or other ornamental stone, or for ornamental concrete work. Analysis show the sand to be almost absolutely pure silica and we are informed that the deposit is of considerable extent.

THE EFFECT UPON STEEL OF WORK AT DIFFERENT TEMPERATURES.*

By C. H. Ridsdale.†

Let us follow the main changes which take place in steel, and see how they affect its properties whilst it passes from the molten state until it becomes solid and cold, and vice versa, and, avoiding as far as possible the use of scientific terms (and perhaps at the risk of strict

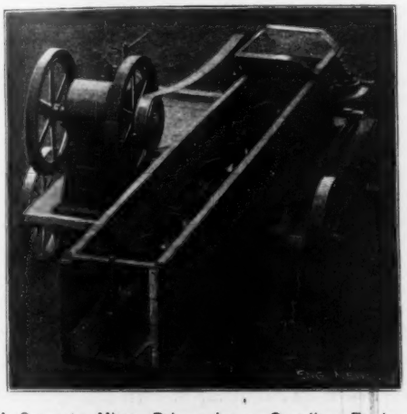
*Extract from a paper on the correct treatment of steel, read before the Iron and Steel Institute of Great Britain at the Glasgow Engineering Congress, Sept. 4, 1901.

†Middlesborough, England.

A PORTABLE CONCRETE-MIXING PLANT.

We illustrate herewith a convenient little outfit for concrete mixing designed especially for street work or similar places where the mixer must be frequently moved from place to place. The mixer is of the screw-conveyor type, and the materials shoveled into the hopper at one end are mixed and delivered at the other. Power is furnished by a little gasoline engine mounted on the same platform with the mixer. The platform has a leg at the delivery end and a tongue at the other. The leg supports the platform when the mixer is in use, and the tongue may be attached to the rear of a wagon when the mixer is to be moved. This machine has been put on the market by the Jeffrey Manufacturing Co., of Columbus, O.

The only defect of this mixer is one which it shares with every mixer of what may be called the "continuous flow type." If you feed a steady stream of stone, cement, sand and water into one end of any such machine, and in exactly the right proportions, the machine will mix these materials and will turn out in most cases a product with which no fault can be found. But the trouble is to feed any such machine in any such uniform manner, and keep the proportions of the different materials anything like correct. If it has ever been done, we do not know when or where. We cheerfully admit that a skilful and conscientious foreman with men who are experienced in the work can feed such a machine in such a manner as to make good concrete; but eternal vigilance is its price. A very little variation in the work of the shoveling gang at one end of the machine



A Concrete Mixer Driven by a Gasoline Engine. Jeffrey Mfg. Co., Columbus, O., Makers.

will cause a variation in the product at the other end, and may mean either a weak spot in the concrete or a waste of cement.

This, more than anything else, we believe, is responsible for the prejudice which still remains among engineers against machine-mixed concrete, and for the common saying that a good man with a shovel can beat any concrete mixer.

On the other hand, it is probably true that the actual mixing done by the screw conveyor type of mixer, if well designed, is if anything more thorough than that done by the mixers working on the "batch" principle, where the materials at times give trouble by pocketing and sticking in the corners. Engineers, however, generally prefer the "batch" mixer of which the well-known cubical box is a good example. Here they can measure out so much stone, so much cement, and so much sand when the mixer is filled, and be sure of their proportions.

The moral of all this, it seems to us, is that in using any continuous flow mixer, operations should be so conducted that the concrete will be made in batches. The materials shou'd be measured onto a platform and shoveled from there into the hopper of the machine, which should be made large enough to hold a batch, and the machine should not be started till the batch has all been shoveled into the hopper. At the other end, too, the mixed concrete should deliver into a hopper, which should take the whole batch before being emptied. The mixing which will take place in flowing from one hopper to the machine and from the second hopper to barrow or dump car will to a large extent neutralize the variations in the composition of the mixture in its passage through the machine.

BOOK REVIEWS.

HOW TO BECOME A GOOD MECHANIC.—By John Phin, author of the "Workshop Companion," etc. Second Edition. New York: Industrial Publication Co. Paper; 5 × 7¼ ins.; pp. 68. 25 cts.

The author does not attempt to teach a mechanic his trade, but confines himself to general good advice as to the methods to be followed by the apprentice in an attempt to advance.

REGULATING RAILROAD TRAFFIC: The Community of Interest's Method in Its Historic Aspects.—By Joseph Nimmo, Jr., LL. D. Published by the author, 1831 F St., N. W., Washington, D. C. Cloth; 5 × 8 ins.; pp. 46.

The author defends railway combinations in all their forms, but is so palpably one-sided in his argument that it is much to be doubted whether his plea will convince those who may read it.

EXPERTISES ET ARBITRAGES.—Par F. Rigaud, Ancien Ingenieur en Chef des Mines, Expert pres la Cour d'Appel de Paris. Encyclopedie Scientifique des Aide-Memoire. Paris: Gauthier-Villars, Quai des Grands-Augustins 55. Paper; 4⅝ × 7¼ ins.; pp. 177. 2.50 francs.

The purpose of the author of this work, who is himself an expert before the Paris Court of Appeals, is to furnish general rules for the guidance of those who are called upon to act as experts or arbitrators in the law courts of France. And he assumes that these experts are selected for their technical rather than for their legal knowledge and experience. He quotes largely from the works of Dalloz, Sorèy, Rousseau-Laisney and Labori upon this subject, and gives a historical résume of decisions by arbitration—the oldest form of judgment in the world. He then proceeds to discuss the duties, obligations, order of proceeding, compensation, etc., of experts appointed by the various courts of France. In a separate section M. Rigaud takes up the general principles of arbitration, and the proper operation of these principles down to the execution of the sentence. While French law only is here considered—and in France the experts are usually called by the court—there is much useful general information in this volume on a much-discussed subject.

TUGMAN'S INDEX TO THE MANUFACTURERS OF THE UNITED STATES. Vol. 1, Pennsylvania: The Tugman Co., 14 So. Broad St., Philadelphia, Pa. Cloth; 9½ × 6½ ins.; pp. 648 + L. $5.00.

This is the second edition of Vol. I. of a series of directories of the manufacturers of the United States, compiled for reference in domestic and foreign trade. The complete set of volumes is planned to contain upwards of 150,000 manufacturers and 10,000 classifications. The present volume covers only the state of Pennsylvania.

The heading to each classification is printed in English, French, German, Spanish and Portuguese. The headings are arranged alphabetically according to the English language, but most detailed indexes for each of the five languages separately are given at the end of the volume. With the name of each manufacturer are several letters and numbers, or symbols, indicating whether the firm to which the symbols attached refer, wishes to handle foreign orders, how it prefers to have such orders received, whether connected with one of the large combinations, the capital stock, and other particulars of interest to home and foreign buyers. The cable addresses of upwards of 400 Pennsylvania firms are also given, together with the names of several hundred lawyers throughout the state.

The average trade directory is a most slovenly compilation, containing as a rule a large number of names which should be excluded. The present work, however, bears evidence of much conscientious care, and so long as it remains up to date should be a most valuable aid to those having occasion to consult such volumes. A curious typographical feature of the work is the adoption of Coy, as the abbreviation for the word "Company."

TECHNICAL ASSISTANT FOR THE CONVEYING AND STORAGE OF CRUDE MATERIALS IN BULK (Technische Hulfsmittel zur Beforderung und Lagerund von Sammelkorpern [Massenguternj).—By M. Buhle. Berlin: Julius Springer. Part I. Cloth; 9 × 12½ ins.; pp. 160; 567 illustrations. Price, $4.50.

The translation of the title of this work, given above, hardly conveys an accurate idea of its scope. It is really a very complete yet concise illustrated treatise on the conveying and storage of bulk materials, such as grain, coal and ore. The illustrations are invariably too small to be of value as scale or detail drawings, but they serve the purpose of showing the general scheme along which the various plants that are described have been worked out. The prime object of the book is to lay before the student a record of the latest improvements in the class of work here dealt with and the methods that are followed by various firms in different parts of the world. The first chapter is devoted to the pneumatic handling of grain, and in it there are 46 illustrations of various English and German devices. These elevators are shown as working at Hamburg, Manchester and London, but no examples are given of this class of work from the United States. In the second and third chapters, however, which deal with the handling and storage of heavy materials, we recognize a number of familiar designs that have been brought to perfection in this country. There are sections of buildings showing the methods of handling coal and ashes and many plans of wharves and yards for coal and iron ore traffic. In this there are shown the steel cars of large capacity that have recently become such a prominent feature in American railroad service, together with the hoists, buckets and runways by which these cars are loaded. These chapters contain many examples taken from American practice, and the illustrations include such notable plants as the power house of the Brooklyn Heights Ry., the coaling station of the New York, New Haven & Hartford R. R., at New Haven, and coaling and conveying plants by Hunt, Brown, the Link Belt Engineering Co. and other American firms. This is followed by systems of coaling ships and locomotives. The third chapter also includes descriptions of a number of boiler houses, a majority of which are located in America. These include such examples as those of the Juniata shops at Altoona, the Philadelphia Traction Co., Mt. Royal pumping station at Baltimore and others.

The book does not enter at all into the minor details of construction, but embraces within its pages a great mass of material that practically covers the whole field of the storage and transportation of crude material in bulk. It is a sort of compendium showing the state of the art, and at the same time presenting it in such a way as to be suggestive and of assistance to the engineer or manager who is confronted with a problem of this sort to be solved.

PRACTICAL TREATISE ON MARINE ENGINES, AUXILIARY ENGINES AND OIL AND GAS ENGINES (Traite Pratique des Machines Marines Motrices, des Machines Auxiliares, des Machines a Petrole et a Gaz).—By J. B. Grard, Inspecting Engineer of the French Navy. Paris: Ch. Beranger, Libraire Polytechnique, 15 Rue des Saints Peres. Cloth; 5⅜ × 8¼ ins.; 2 vols.; pp. 906 and 506; 33 plates and 809 cuts. Price, $7.50.

This ambitious work aims to deal, as its title implies, with the subject of the marine steam engine from a practical rather than a theoretical point of view, and is made up largely of descriptions and illustrations of various details of machinery and mechanism as applied to vessels of the French navy. Beginning with the arrangements of cylinders in engines of different types, the several parts are considered, including the cylinders themselves, the steam jackets, relief valves, pistons and piston packing, etc., the types used in various vessels being separately described. Valves and valve gear are next considered, together with reversing engines, all described in detail and at considerable length, but with little discussion as to the respective merits. The Bonjour system of hydraulic operation of the slide valves is described, the system being adapted to large main engines, but not under high pressures or for high speeds. The shafts, eccentrics, connecting rods, shaft and thrust bearings are then taken up, the discussion involving numerous mathematical demonstrations. Then follow the condensers, air pumps, feed pumps, lubricators, etc., this first chapter of "Description of the Engines" occupying 532 pages. The second chapter deals with the erection of engines of various types (vertical and horizontal) in the vessel's hull, including the lining up, blocking, handling of heavy parts, etc. The third chapter deals with side-wheels and screw propellers, these two chapters being quite short. Another long chapter (300 pages) then deals with the regulation of the engines, the physics of steam, the distribution of steam in the cylinders and the use of valve gears, cut-off gears, etc., in relation to this distribution. Indicators and indicator diagrams here come in for considerable attention, and this chapter is necessarily somewhat mathematical in its treatment.

The second volume opens with a chapter on the management, maintenance and repair of marine engines and boilers of various kinds, giving instruction as to the care of the main and auxiliary engines, and presenting forms for the engineer's logs or reports. This is followed by a chapter on the calculation of the power of the engines. The hydraulic and electric machinery for turning the turrets, handling the guns and raising the ammunition is then considered. The auxiliary engines are next taken up, including steam steering engines, winch and capstan engines, boat cranes and engines for dynamos and pumps. Air compressors to supply compressed air for the torpedoes are given a chapter to themselves, as are the various oils and fuels. Three separate chapters are then devoted, respectively, to oil and gas engines, engine counters and diving apparatus. The last chapter contains general descriptions of a number of marine engines of various types on individual vessels, illustrated by cuts and folding plates.

The illustrations are largely diagrammatic, and many of them are over-reduced, so that the letters and figures are obscure. On the whole, however, they serve their purpose very well, and from the fact that there are over 30 plates and 800 cuts, it will be seen that the descriptive matter is very liberally illustrated. The books are clearly and compactly printed on light paper, with small (but sufficient) margins, so that even the first volume, with its 900 pages, is not heavy or unwieldy.

cient work at a temperature below critical point; the higher the temperature the more this is so, and the slower the cooling the more it is visible when cold. The same law is always ready to come into operation even at lower temperatures, but at or near blue heat the cement is so stiff and offers so much resistance that it is unable to do so, although at temperatures considerably below the critical point—the lower reds—provided the time is sufficiently long, a similar result is obtained. Annealing may in either of the above ways be carried too far so as to be injurious.

Fatigue and restoration by rest come under this category, as they are a continuation of the law at still lower temperatures, but as these are not strictly "treatment" they are not discussed here. The converse fracture by vibration and alleged growth of grain, and consequent brittleness or loss of nature (strain or incipient rupture), might be considered "treatment," as being a contributory cause to faults developed; probably when this occurs the coarse grain was already existent, and rupture only ensues from vibration causing cracks to develop.

When the temperature rises considerably above critical point, and approaches setting or melting point, the cement again becomes too soft to hold the grains firmly, and their coherency becoming less the stage of "red-shortness" is once more reached. Thus we see one reason why overheating produces red-shortness. Another is the burning out of the carbon from the carbide of iron in the small quantity of cement; thus it loses its nature and ceases to act as such, or, if carried too far, not only may the carbon have been burned out, but there may be even substituted a film of oxide, which reduces cohesion still further. It is easy to understand from the above how the presence of a little carbon, say, 0.1% to 0.15% (or similarly of manganese, silicon, and possibly even phosphorus), enables the steel to stand more fire (i. e., heating for a longer time or to a higher heat, provided it is below the temperature of red-shortness) without exhibiting want of cohesion during or after working from this cause, this quantity taking longer to burn out than, say, 0.05% to 0.07%, but at the same time if it gets higher than this there is so much more cement that it becomes soft too readily, and the grain is too much cushioned and does not get worked enough; hence higher carbon steel requires to be worked at a lower temperature for the grain to be sufficiently acted on, and at lower temperatures strains are more readily set up. Similarly steels with little or no carbon (like iron) have so little cement that they do not lose their coherency at a temperature at which higher carbon steel with more cement would, and hence will bear a higher working temperature without falling to pieces, though they are better without it unless wanted very soft.

The behavior of steel at different temperatures would seem to suggest the occurrence of the changes in the "grain" and "cement" whilst reheating, indicated by Fig. 2.

TREATMENT BY THE MAKER TILL IT LEAVES HIS HANDS.

ROLLING INGOTS.—(a) For steel which is going to be reheated and worked further exactly as it is sent away, without undergoing any preliminary process, the limits of the temperature at which work is finished are not set by and are immaterial so far as their effect on its ultimate properties are concerned, since whether it is finished hot or cold and the grain is too large or too small, the respective effects of this will (as has previously been shown) be completely removed on reheating and working further.

But the maker is forced for his own sake to observe certain limits; for if he rolls too hot or before his ingots are set he will make defectives, whilst if he rolls too cold he will strain his machinery, and in either case his sections will be wrong, and these limits more than cover the requirements of the properties of the finished steel.

(b) If the steel is not going to be reheated and worked till it has received some preliminary treatment (such as cold shearing), or if it will be used without further treatment, the finishing temperature and rate of cooling do matter. There should, of course, be sufficient work at a sufficiently low temperature to well knead the material and reduce its grain, thus making it tough, but it must also be finished at a sufficiently high temperature to avoid inducing brittleness or undue rolling hardness. Unless in exceptional instances and for special purposes, above bridge-red 850° to 900° C. is too high, and below low-red 600° to 700° is too low. The exact temperature must be determined for each particular case and according to tests required.

For example, in rails. So long as these meet the specified tests without difficulty, it may not be thought worth while taking any steps to follow exact scientific principles, even though the quality of the material would be rendered still better thereby. Medium heavy sections generally finish within the right limits and meet the tests easily, but it sometimes happens with the two extreme weights they are not so readily met.

Heavy sections, particularly double-head and bull-head, 80 lbs. to 100 lbs. The tendency is to finish at too high a temperature and get too large a grain, especially as they are hard (carbon, 0.35% to 0.50%), and pack on the bank into a close solid mass, and thus cool slowly. They may be quite soft to dead load, but wanting in toughness under ball-test on account of this large grain.

When they cannot be rolled cool enough (say, low-red), they might, perhaps, be air-cooled more rapidly by spreading or other means.

Light sections, particularly flange rails, 35 lbs. to 50 lbs. The tendency is to finish at too low a temperature, especially for the flanges. This is the more so as they do not pack so solidly together. They may be very rigid under dead load and show too hard, or be wanting in toughness under ball-test, owing to the thin parts being rolled too cold, and the strain set up by the unequal finishing temperature and rate of cooling. If they can be finished hotter—say, the heads "good" or cherry-red—or by any means massed more and the surplus heat from the head made to retard the cooling of the flange, such as standing them alternately on their flanges and heads, this ought to be beneficial. An arrangement of this nature is adopted at Homestead on the intermediate cooling-bench, and is being introduced at other American works.

GIRDERS AND OTHER "SECTIONS."—These being used for structural purposes or without further treatment than drilling, the finishing temperature and cooling may usually be regulated, mainly with reference to giving the right tests, so long as the extremes mentioned in the general directions are avoided. This will generally be from "low" to bright cherry-red.

PLATES.—Much the same may be said of these, but they may receive treatment which will develop brittleness that it will probably be out of the power of the maker to anticipate and counteract. (This to be described for users of plates.) As these may have to be sheared, note next paragraph.

BARS WHICH HAVE TO BE COLD-SHEARED BEFORE REHEATING.—As these should cut soft, it is very important, especially the larger the mass, that they should be finished at a good cherry to bright red (say, 800° to 900° C.), well above anything like blue heat, and cooled slowly, and should not be in any way chilled, especially at or near blue heat, either entirely or locally. Even chilling right out from red-hot would not have half so injurious an effect.

Any chilling of a mass by which a part is chilled for some time may be particularly detrimental, as the hotter parts may maintain the part being chilled at a blue heat all the time the mass is cooling, and the strains be intensified thereby. As an instance, on a wet day, a leaky roof letting water trickle on to a bar or plate all the time it is cooling, or chilling with a hose, if in haste to load the material, may set up very great strains. Cooling strains are well recognized in castings, and great attention is paid to proper stripping, etc. However, even should the bar cut brittle through finishing too hot or too cold, or through chilling, the harm ends here, as once it is reheated and reworked all injurious effects will be completely removed. The top and bottom limits of temperature between which work should be finished are shown approximately on the accompanying diagram, Fig. 3.

Neither the critical temperature nor the best finishing temperatures can be measured accurately, as they can only be judged in practice by the eye, and the description of what this sees may not convey the same idea to others. In this diagram Campion's limit for best results for carbon—0.44% to 0.20% for reheating (= "W") is marked C on dotted line.

Ridsdale's limit for best results for carbon—0.16% to 0.03% for continuing work down to, is marked R on full line. If, as per Howe, 30° is deducted (from Campion's figures) to give temperature to continue work down to—i. e., for material cooling (= "V"). The best finishing temperature may be higher or lower, according to mass, etc., and not always within these limits. Thus the finishing temperature given by Hunt for 80-lb. rails at Edgar-Thompson are marked E T; the finishing temperature given by Hunt for rails at Joliet are marked J. The critical temperatures (at which grain begins to be appreciably affected by work) will be above the top limit of the "best" temperatures, and if it can be [illegible] goods with them will probably follow the cross hatched [illegible].

It should be borne in mind that the larger the mass the less work it will have received (besides cooling hotter inside than it appears to be), and hence the larger its grain and the more slowly it will cool; so it should be finished cooler than a smaller mass which will cool more rapidly, or else the large sections should be spread out and cooled more rapidly, and small sections be massed and cooled more slowly.

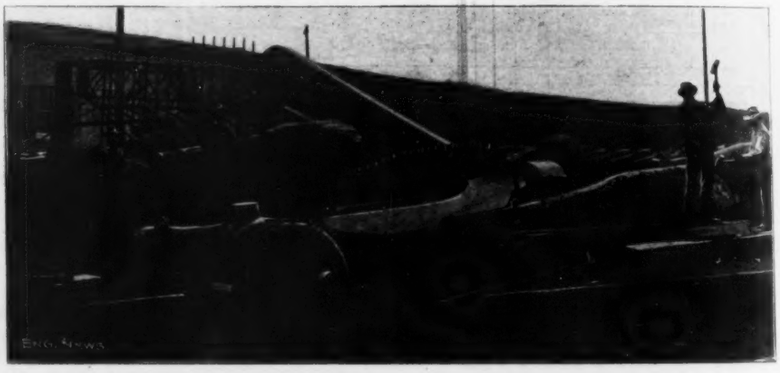
(Concluded next week.)

BREAKING UP 15-IN. CAST-IRON GUNS.

By Frank H. Green.*

Some months ago a large number of old cannon were sold at the Mare Island Navy Yard. The largest of these guns were 15-in. smooth-bore Dahlgrens of cast iron, made in the early '60's. The problem which confronted the purchasers was how to break them up into pieces of merchantable shape, which in this instance must not be larger than about 200 lbs. weight.

After considering several methods and making some experiments, the contractors, Bernstein & Co., of San Francisco, adopted the method of drilling rows of longitudinal holes, driving steel wedges in these holes till the gun split open, and later breaking the parts into smaller pieces with giant powder. The method of drilling and splitting by wedges is plainly shown in the illustration. The guns were jacked up on roller bearings so they could be easily revolved and a frame carrying 15 drills was set over the gun. The holes were 1 in. in diameter and about 7 ins. deep. After drilling one set of holes, the drill was shifted endwise about 4 ins., and a second set of holes was drilled. In this way rows of holes about 4 ins. apart were drilled entirely around the gun, the rows being spaced about 8 ins. apart on the circumference. The drills were operated by a 30-HP. induction motor with current from the Yards & Docks generator.



BREAKING UP 15-IN. DAHLGREN GUNS AT MARE ISLAND NAVY-YARD, CALIFORNIA.

The guns were split open with steel wedges. Two men using 12-lb. sledges opened one gun in a day. An effort was made to continue the splitting by wedges, but this was unsuccessful and powder was used to finish. A barricade or bulkhead of 12 × 12-in. timbers was built over the pieces and under this the segments were broken into small fragments with sticks of 40% nitro-glycerine powder inserted in the holes and fired. Each gun weighed 42,000 lbs., and it required two men four weeks to drill it, and then two weeks more to break it up with wedges and powder.

One of the most interesting things in the illustration is the enormous power of the wedges. Near the breach the thickness of metal was 17 ins., and this thickness tapered to the muzzle, where it was 3 ins. A start was made near the muzzle and then as the metal cracked it was followed back until the breach opened as nicely as a hickory log. Some of these guns had never been fired, and these were much more difficult to break up than others.

The photograph from which the illustration was made was kindly supplied to the writer by Mr. Pitkin, of Vallejo, Cal.

*Vallejo, Cal.

be arranged for rapid action, and fifth, they must be of the two-way and not of the double-throw variety.

High-tension fuses should have an insulation to ground equal to the line insulation, and they should be enclosed in parallel tubes so that arcs may not pass from one to the other.

All high-tension wiring and all possible high-tension switch parts should be rubber covered, or at least weatherproof where great economy is necessary. Switches and fuses should be well separated and as much room as is available should be used.

Substation operation should be practically the same as generating station operation, and in throwing transformers on to a high-tension line whenever there is more than one set of transformers on hand, the station should be arranged so that if one set is in operation the other set may be thrown in on the low-tension side first and the high-tension switches then closed. Even where the transformers are used to feed independent circuits from the substation, it would be advisable to arrange double-throw low-tension switches so that they may be thrown in on the same circuit until after the high-tension switches are closed, and then be thrown over to their own circuit. It would even be advisable, in case two transmission lines were running non-synchronously, to throw them in multiple by switches M. 1 and M. 2 in order to make this connection of an additional set of transformers.

It may not be dangerous to throw transformers in at substations when there is a case of emergency, but this operation, when repeated, has the usual effect of a repeated abnormal strain and will eventually bring about bad results.

Lightning arrester apparatus, which is so frequently wrecked on account of sparks passing over it occasioned by switching lines of transformers in and out, is preserved and kept from carbonizing and short circuiting by this method of operation. Line insulators receive less strain, and frequently punctures are avoided.

The Independent Electric Light & Power Co.'s plant in San Francisco is arranged in this way, and it was a very fortunate arrangement, as it was found impossible to disconnect the underground cables from the transformers feeding them when the current was on without danger of puncturing the cable insulation.

The above method has been used ever since this plant started its operations, and no complications have interfered with the rapid and effective operation of cables and transformers.

Experiences of the Central California System.

By R. W. Van Norden.

When the transmission of the Central California Electric Co. was installed, marble plug switchboards were provided at the receiving end of the 15,000-volt transmission and later at the Newcastle generating station. Wires from the step-up transformers were connected in multiple to the original three-line wires after passing through aluminum fuses about 18 ins. in length. At the receiving end, after passing through the plug board, three fuses similar to those at the generating station were inserted, and from there the wires fed the bank of lowering transformers. This arrangement proved to be defective on many occasions, as an accident or short circuit at any one transformer or even beyond blew at least two fuses. The plugs had to be pulled only when there was no load, consequently they were of little use.

Later a second bank of transformers was installed at the substation, a second circuit was erected on the transmission line and an additional power house was built at Auburn, six miles distance from Newcastle. The line from Auburn was run directly to the Newcastle power house, and at that point a double plug board was installed so that either power house could be switched on either or both transmission lines. A similar board was placed in the substation, two circuits running from it, one to each bank of transformers. At all three stations individual fused cut-outs were placed on the high-tension side of all transformers, and at the substation single-pole quick-break switches on the low-tension (2,400-volt) side, together with fuses. By this means on any accident to an individual transformer, both high or low-tension fuses would blow and thus cut it out. The use of main line fuses was discontinued in all cases.

In the plug boards the wires lead from the rear to a hard-rubber receptable placed in an opening through the panel, the opening in the receptacle being about 3 ins. in depth, and having connected from the rear with the wire and extending towards the front, a split pin with an enlarged head, the pin being ⅝-in. diameter and 2 ins. long. The plugs are of hard rubber, about 10 ins. in length, and closely fit the receptacle; they enclose a brass bushing which fits over the pin, the flexible rubber-covered cable running into an opening at the side of the plug. The outer end has a brass bushing in which a wooden handle may be inserted to remove the plug.

These plugs and cables have proved to be electrically serviceable, and will break the circuit on a load, although it has never been attempted but once or twice. The cutting in and out of either transmission line or the line to Auburn necessitated by line repairs or for other reasons, very soon injured or partially destroyed the plugs, as it was found very difficult to keep perfect contact between the pin and bushing, and often on full load the plug would get so hot from sparking at the contact as to melt the rubber and make it next to impossible to remove the plug without taking out the entire receptacle. The plugs and cables are very heavy, and clumsy, which makes them difficult to handle. The entire set at the Newcastle power house has been replaced with the Masson-Taylor switch, heavy wire being substituted for fuses.

The individual cut-out fuses consist of a stick of hard wood about 18 ins. in length, on either end of which is a blade of heavy sheet copper extending at right angles to the wooden stick, while between the blades is suspended from a screw in each the copper-wire fuse, over which is slipped a piece of rubber tubing. In the center of the stick is a wooden handle. This cut-out fits into a pair of copper clips soldered to a heavy copper wire, which, in turn, is fastened to a glass insulator. The two insulators are placed so as to give the cut-outs a position about 20° from the perpendicular, excepting at Newcastle, where they are horizontal. We have experienced no difficulty in cutting in and out transformers by this method, and although we have on several occasions had fuses blow on short circuits, the burning of the fuse wire has in every case immediately opened the circuit. We find the new switches at Newcastle an immense improvement over the old apparatus, and they have so far given good satisfaction.

The Martin High Potential Switch.

By F. V. T. Lee.

The Martin High Potential Switch was first designed and built in the spring of 1898, and was designed for the purpose of fulfilling the specifications and requirements of the Yuba Power Co. on its 16,500-volt line.

Briefly, the switch may be described as a double-break single-pole switch, each break being 18 ins. in length, so that the resulting break on the switch proper can be considered as 36 ins. The current enters the upper terminal of the switch and passes through the contact jaws and blade from a conductor which is embedded in soft rubber and then encased within two strips of fiber. At the lower end of this fiber switch bar the current leaves the blade and jaws of the switch to the other terminal of the line. The switch rods on which the switch bar slides are made of cold-rolled steel shafting and the bar and rods run on babbitted bearings throughout. By this construction a very accurate and satisfactory fit is obtained. The method of operation is very simple, as the switch bar when closed is held by a latch, so that there is no possibility of the jaws working loose. When the switch is closed the main operating spring is not in tension, nor, indeed, is it ever in tension except at the instant the switch is thrown. To throw the switch, the switch rods which are connected to the insulated handle are pressed in to their fullest extent, placing the operating spring under considerable tension. Just as the operating handle is pressed home, it releases the latch holding the switch bar, and when so released the switch bar is free to be drawn from the jaws and pulled open to its fullest extent, and, as a result, the switch opens so quickly that the arc is not able to follow and is immediately disrupted.

The Latest Westinghouse Switches.

By W. M. McFarland.

Circuit-opening devices are constructed on the general principle employing the open arc and carbon break. This is obviously the most simple type of apparatus, and one in which the extinction of the arc depends simply on mechanical distance and not upon the character of materials used in constructing the apparatus. Whenever an arc is confined it must necessarily have a deteriorating effect upon the materials with which it comes in contact. When the currents are heavy or voltages are high, it is obvious that very great responsibility is placed upon the integrity of the materials composing the switch. The length of break, or opening of the circuit-breakers, is proportioned to the voltage of the circuit. The arc occurs on carbon terminals above, and well removed from the metal parts of the breaker. The construction of the circuit-breakers aids the natural tendency of the arc to rise and prevents any possibility of communication to any live parts below the carbon terminals.

The Stanley Switches and Circuit-Breakers.

By W. Currie.

The principles embodied in the design of both switch and circuit-breaker are practically the same, the circuit-breaker being a slide switch with a coil and tripping device placed on it so as to open the switch automatically. The circuit-breaker can also be opened in a similar manner as the slide switch, thus ensuring a positive means of breaking the circuit, if any trouble should occur due to the coil which operates the tripping device not acting.

The knife blades are made to slide on parallel rods which serve to support the front and back terminal marbles to the main marble or switchboard and which also guide the blades into the terminal jaw contacts. These blades are thoroughly insulated from the guide rods and are moved back and forth by means of a pull rod which projects through to the front of the board, the pull rod being operated by a rack and pinion on the main marble. Each terminal jaw contact piece is enclosed in a separate insulated box, provided with a shutter, which closes quickly by means of a spring immediately after the blade has been pulled away from the contacts, and thus any arc that may be formed is ruptured. Quick operation and sharp snap break is obtained by means of a spring placed on the main pull rod.

These switches and circuit-breakers are built for the following standard capacities and voltages:

300	amperes at	1,200 volts.
200	"	" 2,400 "
60	"	" 6,600 "

Below 3,000 volts, the switch is designed with two breaks per pole, while above 3,000 volts there are four breaks per pole.

The principle covered in the design of the Stanley oil switches is that on breaking the contact between knife blade and jaw, an insulating fluid, such as oil, is allowed to rush in quickly between jaw and blade, insulating them thoroughly from each other and breaking any arc that may be formed.

Each pole of the switch, consisting of knife blade and terminal jaws, is immersed in oil in a separate cast-iron porcelain-lined tank. These tanks are then mounted on a piece of marble forming the cover for the tanks and on top of which are placed the terminals and mechanical apparatus for the proper operation of the switch. This top marble is mounted on framework at the back of the board and is entirely separate from the front marble of the main switchboard, the only part visible on the front of the board being the operating handle, which is thoroughly insulated from the working parts of the switch, thus avoiding any chance of danger to the operator.

These oil types of switch are built for the following standard capacities and voltages:

1,000	amperes at	2,400 volts.
500	"	" 4,400 "
100	"	" 7,500 "
100	"	" 12,000 "

For voltages above 4,500 volts, the switch is made with four breaks per pole, while below 4,500 volts there are only two breaks per pole.

The plug type of switch depends for its successful operation on the mechanical separation of a receptacle from its terminal plug, quickly and sharply—the arc formed, due to the breaking of the contact, being ruptured in the air on account of the quickness of motion and the distance of separation.

These switches are built for the following standard capacities and voltages:

75	amperes at	6,600 volts.
50	"	" 12,000 "
35	"	" 20,000 "
25	"	" 30,000 "

The type of switch, known as the combination fuse and switch, depends for its successful operation on the drawing of a metal fuse through a non-conducting powder, which is enclosed in a short insulated tube. The arc formed, due to the breaking of contacts, is ruptured as the fuse passes quickly through the powder.

As the combination is primarily a switch and not a fuse, the fuse is made sufficiently heavy so as to avoid its blowing under anything but extreme conditions. If, on any account, the fuse should blow, the action is precisely the same as in the switch, except that the break takes place in the center of the tube instead of at the jaws. These switches are built for any voltage from 10,000 to 60,000 volts, or even higher. They are in use on the 40,000-volt circuits of the Standard Electric Co. of California and the Bay Counties Power Co.

Experience of the Montana Power Transmission Company.

By Max Hebgen.

We are using the ordinary high-tension switch made by the General Electric Co. on our 16,000-volt transmission line from the Big Hole River to Butte, a distance of 22 miles, nevertheless we never open them under short circuits or troubles. We use them only for breaking the charging currents of the line and for changing transformers from one line to another. In case of trouble on the line such as short circuits and breaks, we make no attempt to open any switches, but allow the machines to burn off the short or trouble if possible, and if not, then we shut down and clear off the trouble.

Personally, I believe in oil switches. We are using them up to 2,000 volts, and in my opinion they will in time be the only style of switch used in high-tension work. Furthermore, I think it is only a question of a short time when they will be used to the exclusion of every other variety.

Discussion.

Mr. Poole.—I agree with Mr. Masson that high-tension switching should be done on the low-tension side, wherever possible. Before throwing our high-tension switches, we make sure that the low-tension switches are open, and find it works very well indeed. To my mind it seems quite possible that extremely high-tension switching may be done in submerged switches. There may be an elastic limit to the carbonizing effects of oil, and things of that kind, but if you can get a liquid of some kind that will not so suffer, distilled water for example, it seems to me we may look forward to some switch of that sort for high-tension work.

Mr. Masson.—In the little diagram, Fig. 1, is shown the general plan that is used by the Independent Electric

REPORTS ON ENGINEERING INVESTIGATIONS (Mitteilungen uber Forshungsarbeiten auf dem Gebiete des Ingenieurwesens), from the German Society of Engineers. Berlin: Julius Springer. Part II. Paper; 7½ x 10½ ins.; pp. 73; illustrated. Price, 30 cts.

These are four reports in this pamphlet and the subjects covered are: Ball Bearings for Various Loadings; The Determination of the Inequalities in the Speeds of Rotating Machines, by the Use of the Tuning Fork; The Connection of Heat through Heating Surfaces; and Some Experiments with Pneumatic Hammers.

It may be said at the outset that formulas based upon the higher mathematics are prominent features of all of these papers. The paper on ball bearings opens with the statement that for some time the author had been engaged at the Berlin manufactory of arms and ammunition, and had found that there was comparatively little information regarding the possible loading and frictional resistance of ball bearings. And, when the subject is opened, it is found to develop many questions for investigation. At the outset the author gives in detail the results obtained both mathematically and with the testing machine in the matter of the compression of hardened steel balls and plates, illustrating the methods and apparatus used. Then follows a number of diagrams showing the action of balls when loaded to about their elastic limit and the dependence of this loading upon the diameters. A large number of experiments are detailed on the frictional resistance of this type of bearing with various sizes of balls and shapes of plates.

The second paper on the use of the tuning fork for the detection of irregularity of action in rotating machines opens with a brief mathematical introduction to the subject, which is followed by a short account of early investigations along this line. Then comes a description of the methods used in the work here described, and diagrams, tables and mathematical analysis of the results obtained.

The third paper on the convection of heat through heating surfaces, describes a peculiar apparatus that was used for the experiments in question. A hollow cylinder of red brass, having a hemispherical bottom, and which contained some boiling water, was set down into a liquid bath that could be heated with a gas-burner. Fastened to the upper rim of the cylinder, which was submerged in the liquid, was an extension made of a thin plate of yellow brass, which prevented the boiling water from spattering into the outer bath. At first paraffine and afterwards palm oil was used for the bath. A stirring apparatus driven by an electric motor was set down into the liquid of the bath and served to keep it in rapid circulation. The entrance of heat into the brass cylinder, aside from the temperature of the bath, naturally depends upon the rapidity of convection through the metal.

The fourth and last paper is a detailed account of an investigation of a pneumatic hammer in order to obtain the data needed for a calculation of its efficiency.

THE CONSTRUCTION OF A GASOLENE MOTOR VEHICLE.—C. C. Bramwell. New York: Emil Grossman & Bro. Cloth; 6 x 9 ins.; pp. 149; illustrated. $2.00.

This series of articles on the gasolene motor was originally written for the "Motor Vehicle Review." It is intended to set forth the principles of operation in such vehicles; to show the advantages and disadvantages of various methods of mixing gasolene and air; to discuss the methods of ignition by the electric spark, and to show the detailed construction of motors of this type, and their mounting in vehicles of different classes.

ELECTRIC SWITCHES AND FUSES FOR CURRENTS OF VERY HIGH VOLTAGE.

At the fifth annual meeting of the Pacific Coast Electric Transmission Association, held at San Jose, Cal., on June 18 and 19, 1901, a number of papers were presented describing the construction of electric switches for high-tension currents, and relating the experience which had been had with these devices. The papers were printed in "The Journal of Electricity, Power and Gas," of San Francisco, for June. In connection with the extended description of the Bay Counties Power Co.'s long-distance transmission plant, given elsewhere in this issue, these papers are of especial interest, and we abstract those of most importance, together with the discussion upon them, as follows:

Some Suggestions in High-Tension Switching.

By R. S. Masson.

High-tension switching is best done when it is not done at all. Circuits having a source of electric-motive force and power each side of a switch may be disconnected without shock or spark, provided no great amount of power is flowing past the switch. This disconnecting is hardly known as switching, and is not harmful. Many plants have for years successfully avoided all high-tension transformer troubles, until increased capacity or excessive prosperity caused the introduction of high-tension fuses or switches, and troubles arrived forthwith. The switches and fuses themselves are harmless and beneficial, but the improper use of them is objectionable.

Abnormal strains are introduced into the insulation of high-tension circuits by many causes, among which the following are the most common: (1) Atmospheric discharge. (The heavy disruptive discharge is called lightning. The lighter forms are known as "static"). (2) Sudden short circuits, or grounds on the circuits. (3) Changing and unbalancing the electro-static capacity of the circuit by switching, fusing, etc.

The first erratic frequenter cannot be avoided, but by proper devices may usually be kept from damaging the apparatus. These discharges are more or less effective, depending upon the distance at which the discharge takes place from the apparatus liable to be damaged. The second occurrence is unavoidable, except as influenced by good construction work. Its effects also depend upon the relative location of the short circuit and the apparatus to be protected. The third class of disturbances—switching and fusing—is directly in the control of the engineer and is very close to the apparatus which is endangered. Many engineers—including the writer—have made the error of placing switches inside the lightning protection apparatus. This is usually forced upon the engineer by the high cost of lightning apparatus, but the system here described avoids the difficulty.

Connecting one or two wires of a long line to a set of transformers gives a badly balanced electro-static condition which causes a heavy static discharge from the low-tension coils of the transformers, and, in many cases, a discharge over the high-tension lightning arresters, thus showing a very high strain upon the general insulation. Making a circuit causes strains nearly as great as breaking it, although not accompanied by the usual pyrotechnic demonstrations.

Fuses are safe enough if arranged at the terminals so as to avoid blowing by bad contact.* Blowing a fuse is always accompanied by heavy-load currents, which

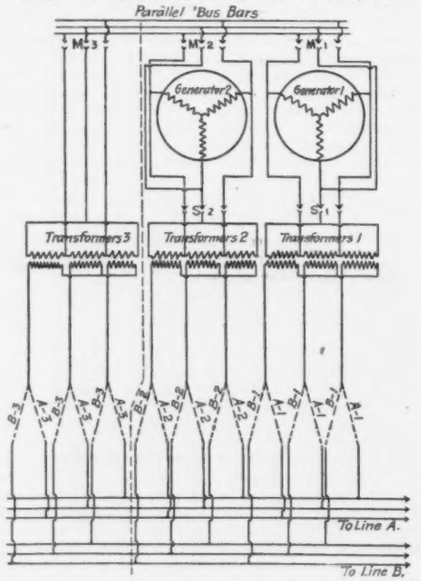


Fig. 1. Diagram Illustrating the Manipulation of High-Tension Switches.

render the static break-down effect less, if not entirely harmless.

All danger of switching can be avoided by proper arrangements and method of operation. The one fact to be kept in mind in arranging a station's wiring and switches is that no high-tension circuit should be made or broken unless there is a source of electro-motive force and power on each side of the switch, and—when closing —that both sides are in synchronism or that there is no current at all on it. This can usually be done as follows:

Six cases arise, which, with slight changes, represent nearly every generating station installation.

(1) 1 Generator; 1 Set of Transformers; 1 Transmission Line.

(2) 1 Generator; 2 Sets of Transformers; 1 Transmission Line.

(3) 2 Generators; 2 Sets of Transformers; 1 Transmission Line.

(4) 2 Generators; 2 Sets of Transformers; 2 Transmission Lines.

(5) 2 Generators; 3 Sets of Transformers; 2 Transmission Lines.

(6) 3 Generators; 3 Sets of Transformers; 2 Transmission Lines.

In case (1) no switches or fuses are needed, either on generators or on the low or high tension sides of transformers. No advantage can possibly be shown in having an operator open a switch when he stops the plant, or gallantly close it in starting after "he" is [illegible] voltage. Nor is there any advantage in the barbarous fusing of early days, when protection was needed to keep a machine from carrying full load for fear of [illegible] winding from the armature, which remedy, by the way, usually arrived too late to do good—in fact it was generally applied just in time to add a switch-[illegible] grief to the wreck of an armature. Fuses should be used to protect the apparatus beyond the fuses, and [illegible] the apparatus toward the source of power. This rule—it should be a rule—is the most abused of them all.

A motor may be protected by a fuse of a size equal to the current which will injure the motor; a line may be protected by a fuse of a size equal to the current which can injure the wire; a generator may be protected by its driving power—the size of the water-wheel [illegible] equal the point at which the generator may be injured [illegible] one-half minute—or the time it takes to shut off the water. A water-wheel may be protected by the size of its nozzle, but to protect a generator by the fuse going to its line is not right in alternating current practice with water-wheel drive. It is much easier to get a plant back to running conditions from a standstill caused by a short circuit than to replace a set of fuses. In protecting one branch circuit against a short circuit on another, fuses may be used to advantage, but the capacity of the fuse should be rated by what is required beyond the fuse. In case (1) a possible exception may be made by having convenient switches or connectors to release one of a set of delta connected transformers, but no automatic devices should be used, as a shut down would probably occur before the automatic fuses could be blown if they were of such size as to render them safe against accidental blowing, and it would be as well to shut down the plant and then open the connectors or switches as to try to have them automatic, when accidental fusing might interfere with constant operation.

In case (2) low and high-tension switches and fuses should be used on the transformers. The line should be connected to the transformer and generator before starting, or at least to a dead set of transformers, and they should then be connected on the low-tension side to the generator. Transformers should be cut in on low-tension side first, closing high-tension side last, and in cutting out transformers, open the high-tension side first. In case (3) the same method as in case (2) should be used. In case (4) more complication arises. Connections for a three-phase delta-y connected set may be made as in Fig. 1.

It should be possible to make the following arrangements of the plant: (a) Start up and run Generator No. 1, Transformer No. 1, on Line No. A. (b) Start up and run Generator No. 1, Transformer No. 2, on Line No. B. (c) Throw above in parallel. (d) Throw Generator No. 1 and Transformer No. 1 on Line No. B in parallel with Generator No. 2 and Transformer No. 2 and clear Line No. A. (e) Restore to condition (c). To do this operate as follows: (a) With Generator No. 1 standing still, close switches A. 1 and S. 1, and start Generator No. 1—or with Generator No. 1 running at full voltage, close switches A. 1, then S. 1. (b) Same as (a) with Generator No. 2. (c) Close switches M. 1 and synchronize M. 2. Then close B and open M. and M. 2. (d) Close M. and M. 2, then quickly open B. Open S. 1. Open A. 1. Close S. 1. Close B. 1. Open M. 1 and M. 2.

The No. 2 Generator thus remains in operation via M. 2 and M. 1, and the power supplied being the same, only the transformers are changed. Even if a full load were on the station, a double load would not injure the transformers for this short time, and only in a case of greatest emergency would a line be cut out at full load. If the load conditions run up to near full load a spare transformer would likely be on hand, and by adding one more we would be equipped as in case (5). (See portion of accompanying Fig. 1 to left of dotted line.) This expense is not prohibitory. (4 e) Close switches M. 1 and M. 2, then quickly open B. 1. Open S. 1. Close A 1. Close S. 1. Then at leisure close B. 1 and A. 2 and open M. 1 and M. 2. Transformer No. 1 may be used on Generator No. 2 by removing the brushes on Generator No. 1 and closing M. 1, M. 2 and S. 1.

Case 5 is like case 4, but needs no quick work, as each set of transformers may be replaced by the third set, and is better than case 4.

Case 6 is so similar to 4 as to need no explanation.

In all operations except these marked "quickly" the switches may be moved slowly, and should be in control, so that if a spark appears the switch may be put in again and the operator may consider the case to see if he has not gone astray. In opening low-tension switches, S. 1, 2 and 3, in cases where the transformer is in circuit, a slight spark follows.

The good effect of the absence of arcs and fireworks by this method of operation must appeal to any station operator.

The high-tension switches for this method of operating need only have the following qualifications: First, the insulation of all parts from ground and each other, equal to the line insulation; second, simplicity of operation; third, they must be capable of being opened slowly and returned if an arc appears, hence a quick break switch would not be suitable for this purpose; fourth, they must

*If aluminum is used, fuses should be renewed once every month.—R. S. M.

Light & Power Co., with the exception that this is shown as a three-phase plant, instead of being two-phase. The general idea was to have a system of holding generators in multiple on the low-tension side, while putting in the high-tension switches in case of putting them parallel. For that purpose we have special busbars on the switchboard, with switches going from the low-tension side of the generator independent of any circuit breakers or switches which throw the generators on to the transformers. That avoids the old trouble of having something like double voltage on the high-tension busbars at the time of throwing in or out the first switch in an attempt to synchronize or separate them. In most high-tension work we have had single-pole switches in this country. Back East they are using three-pole switches, which helps that a little; but it is very much better, if you have two machines out of phase, not to throw in one leg of the circuit, because when you do, if they are passing over the waves, they produce double voltage when they are at opposite points.

In the same connection we have arranged in our plant to open and close all high-tension switches when there is power on both sides of the switch, so we never have a spark unless a man gets mixed up (which he sometimes does). If we throw in the multiple switches, shown at the top of the sketch, and marked M, it holds the machine in multiple with the other machine, which is supplying the line. The two machines being held in multiple on the low-tension side, current being supplied to their transformers through the switches at S, there is no potential difference on two sides of the open high-tension switch. That switch can be closed and opened without any spark at all.

The shock that is produced in any case by a spark is a bad thing, and while it certainly is possible to make a switch that will open any circuit (if there is a big enough building around, or provided we want to use oil, in which case the spark is very short), we cannot remove the shock on the insulation which is due to opening the circuit. No matter whether we break an arc in the air with a gap of 6 ft. in a long flaring arc, or in oil with a gap of 3 ins., we are still producing the same shock on the insulation. I believe that it is only a question of time when the results will be serious.

I find that in substation work it is very nearly as easy to do the same thing. If you wish to throw in a bank of spare transformers, it is a very easy matter to put the low potential in first, unless the transformers are working on a separate job in their own station. In that case, if it is not too much complication, we could even afford to clear a line away back to the power house and start our first bank of transformers from the generator end instead of throwing them in on the line. Where they are working in multiple on busbars, as they usually are in substations, it is merely a matter of closing the low-tension switches first, and then closing the high-tension switches.

The effect on lightning arresters of opening switches is very remarkable. On the Truckee General Electric Co.'s plant they insisted on opening the main-line switches. They have a very dry atmosphere up there, which gives them an extra heavy static charge on the line, and those switches, which are the M-T type, did not open the circuit very well, and, usually, didn't open at all. A switch is always limited to what it can do. It is never definitely certain that a switch will open any particular circuit. It is only a question of its opening a certain number of amperes at a certain voltage and power factor, and if you increase the bad condition on the line, it doesn't make any difference who made the switch; it is not going to open the circuit. They opened the lines every day or two to see that the switches were in good working order, and nearly every time that they opened one of the lines, without load, the lightning arresters broke down under the strain. I think they were what the Westinghouse Co. call Type R lightning arresters, and as they continued to break down, of course there is no question of the results. They were of non-arcing metal and the surface became burned, and after a time there was a short circuit across the lightning arresters. I believe that after they got through with the last experiment they made in that direction the arresters stayed short-circuited, and they are now buying new ones.

It is a bad plan to try these high-tension operations and I believe that a plant would be the better if we didn't try them at all. Every insulator on the line, and every bit of transformer insulation is being strained in a manner which is very similar to the old scheme of testing a boiler by putting two or three times the full steam pressure, thereby straining everything, and then when they do go to work under the regular strain, they will break down.

One plant ran for two years and three months with loads varying from a full load to 25 or 30% overload for periods of seven or eight hours each day, without any transformer difficulties. They didn't have a spare transformer, and they didn't have a spare coil. They did not have a spare lightning arrester, or any lightning arresters. They ran without lightning arresters, and without switches. At the end of this time they became prosperous and wanted to get some spare transformers and coils. They bought two transformers and put one at each end of the line for fear they would have a breakdown, and I think it was about eight days after they got the spare that they had a breakdown. They had several breakdowns within three or four months. When they got the spare they wired it up and put in switches to throw it into circuit right away, and they had tried those switches perhaps a dizen times to see if they could make this connection rapidly under working conditions, and the results were certain. They could make the connection, and they had use for it right away.

Mr. Martin.—I think any manager who would overload his transformers to the extent of 15 or 25% was using bad judgment. I think if the transformers were not subjected to more than a normal load there would have been no trouble.

Mr. Hutton.—One question I would like to ask Mr. Masson, and that is, taking that diagram, say the right-hand figure there, you said something about when you put in one switch you get double voltage. Take that right-hand figure, and supposing we put in the switch on the bottom, how do you make out the double voltage?

Mr. Masson.—In reply to Mr. Hutton, in the diagram, if you have No. 2 generator running on the busbars, the normal way of throwing in No. 1 generator would be to close the high-tension switches first. That eliminates the question of double voltage which I spoke of, but it gives this effect, that your high-tension side of this bank of transformers is unequally charged, or at least, it is charged from a single leg of the high-tension circuit, which, in turn, produces a charge on the low-tension side of this transformer, and through the synchronizing lamps which span the gap S. 1, that static charge is thrown back into the generator. It is very bad to have a static charge go in on a circuit of that sort, and different devices have been used to stop it. Among others is the Westinghouse spark gap, and a similar device, used by several companies, of putting lamps from the center of the transformer to ground, or of grounding the center of a set of transformers of this kind. That static charge is what I was trying to eliminate, and that is eliminated by closing the S. 1 switches from the generator side, and sending the high-tension current up the other way through the transformers.

Mr. Poole.—I would like to ask Mr. Masson if properly constructed lightning arresters will not act as a safeguard against those extreme high voltages produced by the static effects?

Mr. Masson.—With properly constructed lightning arrester you can stop this rise in static voltage at some number of times the normal voltage; say, twice. On an ordinary 15,000 volt circuit it takes about 30,000 volts to break down most of the lightning arresters on the market. Some of the manufacturers do a little better than that, and some a little worse. But if we are running at 15,000 volts, it would be much better not to raise the voltage to 30,000 until necessary. In working, the static voltage does go above the normal, because it passes over the lightning arresters pretty nearly all the time, but if is in a balanced condition, and doesn't seem to have as bad an effect as that which comes on a single side of the circuit. So, while the lightning arresters might protect against this rise in voltage, they would not stop short of about twice the normal voltage, and it would be much better not to produce that strain of twice the normal voltage if we could avoid it.

Another thing: the lightning arresters which are being used are being worn out. A lightning arrester is at its best if not employed at all, except to stand around and look out for lightning, and if we work it on every-day discharges due to the static current we are using it up much faster than we need to use it with the number of lightning discharges that we have, and they are very few. I think lightning arresters on this side of the mountains often have not passed anything more than a fine static spark for two or three years. I think a lightning arrester is a machine like an arc lamp; it wears out: it is used up by the passage of the current, and it would be better not to have these discharges, in order to keep the lightning arresters in first-class condition.

Mr. Stark.—I would like to ask what suggestion Mr. Masson has for putting in a bank of transformers without the use of the high-tension switch? I don't see how it can be done.

Mr. Masson.—If it is a single bank of transformers, situated in a lone substation, or if, for any purpose, the substation is cut out, and the line is working, there is no other way but to throw it in. There are, however, very few substations with but one set of transformers. Still we have them in the pumping plants, but there the transformers can be left in circuit, as far as ordinary practice is concerned, for an indefinite period. I don't think it is advisable to take them out when you don't want them. In a water-power plant, particularly, I would suggest leaving them in at all times, because, when they are not working there is usually plenty of spare capacity, and a little iron loss doesn't hurt anything. In all these cases, I think that the question of repeated strain is the important one. If we do this thing once it is all right. It does a certain amount of harm. But each time that we do it, it does the same amount of harm, and perhaps a transformer would stand a hundred "throwings in," or a thousand, but if we use the switches we are going to arrive at the time when they break down much quicker than if we leave them in, say a month, or six months, or a year, without opening the switches. In all stations where there are two banks of transformers on the same sort of work, there is no trouble whatever in throwing the [illegible] on the low-tension side, and then reversing the ope[illegible] to take them out.

An exception to that is the case where [illegible] two lines feeding the substations are not in synchron[illegible] but I think that should be avoided in operation as [illegible] as possible. It has the same effect on line insul[illegible] to run two separate three-wire lines out of synchr[illegible] so that it has on the switchboards that I referred to, fo[illegible] reason that if any one point on the line happens [illegible] be accidentally connected to one point of the other [illegible] either through a leaky insulator, or in any other [illegible] we immediately get the double voltage on the oth[illegible] insulators of the line, and will probably break them do[illegible] I think that in regulating a plant, if the plant is fortu[illegible] enough to have two lines, so that they can use one [illegible] lighting work, and one for power work, it would be b[illegible] to run them in multiple on the generating station end [illegible] if it does not disturb the voltage too much by the spee[illegible] regulation of the generator. In general there is very li[illegible] trouble in leaving the lines in multiple at the genera[illegible] station end since the greatest part of the disturbance occurs beyond that point.

Mr. Stark.—Where would you advise the fusing of high-tension transformers, if they are not to be disconnected from the line?

Mr. Masson.—Fusing is a bit different from switching. If you put on a fuse which will not blow by resistance through the contacts, there is no serious effect from the static charge of the line, because, when the line fuses it is always connected to a very heavy load at the other end of the line, and if the line is connected to anything at all, even a single bank of transformers, you seldom have any evil effects from switching, and in the case of fusing it is accompanied by a very heavy arc, which lets all of the static charge down before the arc discontinues, and the very fact that it is fusing or short-circuited shows that there is no possible static charge at the other end.

I think in small stations fuses are a luxury, and it has been my custom to make them so big that they never blow. We have had to sell them to a man because he insisted on it, but we make them so they cannot possibly be blown, and you have the best possible condition, except in large plants where the discontinuance of service at one point cannot be allowed to interfere with the other. In these long lines they will have new reasons for putting in fuses, but in the small plants it is very much better not to have any circuit-breakers or fuses at all.

The Independent Company is now operating all the way to the substations without any automatic devices at all. We have locked up the circuit-breakers between generators and transformers, and we never have opened the circuit-breakers between the switchboard and the cables. In that case it was the same thing. We didn't dare let them open on no load. We might have used fuses there, but circuit-breakers we could not use, because they are likely to jar out in time, and our cables were not made to stand opening a 11,000-volt current when the other end of the cable is open. So our circuit-breakers have been tied in on all the underground 11,000-volt service. Our overhead circuit-breakers are working very satisfactorily because we have not blown them out, but I don't think that fuses on high-tension circuits or on any circuits, low tension or high tension, should be employed, unless it is absolutely necessary—besides, a man ought to think about four times before he allows a fuse to blow.

It is safe enough to use fuse to take care of a very heavy short circuit, and in all of our distribution work the fuse tables that we use have for motors about 4½ times the full load current, for lights about twice the full load current, and for arc lamps about three times the full-load current. In the month of May we blew eight fuses altogether, including about 2,000 service fuses, and all of our station apparatus. Of course, on the short-circuit distributing lines we have circuit-breakers which must be used, because the elevator man usually short-circuits his elevator about once a day, hence we must have a circuit-breaker for him; but that is set for a dead short circuit, and doesn't go out at less than about five or six times the full-line current.

Mr. Hutton.—On our Sacramento plant we have four circuits between the generator plant and the substation and we operate them all in parallel. Very often we have trouble with one circuit and, of course, it shuts the whole plant down. I have been figuring on using the same that they are using at the Niagara plant, that is to have circuit-breakers in at the generating station, and reverse current circuit-breakers at the substation.

The trouble Mr. Masson has is on account of having a cable. If you have transformers connected with the cable, the transformer will suffer, and if it is the cable, the insulation of the cable. High-tension lines on poles are a different proposition.

Mr. Masson.—Circuit-breakers are very treacherous at best; you can't tell whether they are going to stay in or not. You must have them set by hair trigger, and hair triggers are bad things in an electric place. I believe in a water-power station, that it is usually better to shut the plant down every time you have trouble, provided your troubles are not too awfully numerous, than it is to use automatic devices; that is, for small electric plants. I am not talking about these 140-mile plants, because

they are forced to use circuit-breakers and all sorts of things, and they will have to develop new lines of apparatus to do that. The standard line won't help their case at all. They will have to have a circuit-breaker that does not jar out, and is not set on a hair trigger, and they will probably be able to tell us more about that than we can guess at present.

Mr. Martin.—All I can say in regard to the Martin switch is that it was originally designed, as outlined in the paper, for use on 16,000-volt circuit, 19 miles in length. A test which would bring out every point that Mr. Masson was speaking of was made by Dr. Perrine, showing the capacity of discharge of local line. At that time the potential was increased to 36,000 volts by placing the two banks of transformers in series on the high tension side. The arc was dissipated quite satisfactorily in less than two seconds. Those switches have filled a certain purpose in the transmission field. They have not been designed for excessively high voltages for the reason that other devices are more suitable. For 5,000 or 10,000 or 15,000 volts they have been very extensively used. In Nevada county there is one switchboard containing 64.

Mr. Lighthipe.—The General Electric Co. is following distinctly an oil switch for high potential and all heavy circuits. We have been creeping up on our high potential switches from 10,000 volts on up. When I was East last year they were working on a 22,000-volt switch, which has since been standardized, and I think we will soon have a 40,000-volt switch on the market. As Mr. Masson suggests, if you have plenty of sky room you can open anything, but as a rule we have not room in the station, and the trouble with the high potential switches on the Truckee station and the Truckee substation, or the Somstock substation, is the lack of room to work those switches. I think they are afraid to use them. Where you must open a high potential switch in a very confined space, and be sure of smothering it, I think the oil switch is the future switch for high potential work.

The switches that we are using on the Metropolitan R. R. are not very high, but they open very heavy circuits, and each switch is single-poled and confined in a brick fireproof vault and worked pneumatically, and they have stood the test of time very well indeed. The switch in the Metropolitan station is probably 80 ft. away from the man that operates it. They have had absolutely no trouble in switching 5,000 or 6,000 volts, and as high as 3,000 or 4,000 amperes. The arc is broken instantly by being submerged in oil.

We cannot afford to have an arc that will carry 9 or 10 or 12 ft. in the air, and you don't know what it is going to hit. We found that out in Southern California when we attempted to open that open switch, where we had a short circuit, and the arc simply sizzled all around the roof of the station, and we had to short-circuit the entire line to the several substations. There is no room for 30,000-volt switches in any substations I have seen. I don't want to criticise any switchboard, but I would very much dislike opening the switches at Piedmont on account of the proximity of the corrugated roof of the station. I think a 30,000 or 40,000-volt switch opened with a load on would carry an arc 10 or 15 ft. long, and if it hasn't plenty of head room to break it is going to catch onto something. It don't take long to make a hole in the roof, either. I think the future development of all this high potential work is to confine switches in a small space and submerge all the breaking parts in oil.

Mr. Poole.—Mr. Lighthipe's suggestion that you require plenty of room for opening the switches in the air I think is very well taken; but I can say that we have opened one of our 40,000-volt switches, carrying 42,000 volts experimentally, and the arc was very pretty for a time, about as large around as your arm. We thought it worked very satisfactorily indeed. That was done without having the fuse enclosed in a non-arcing substance, such as the Standard Co. recommends; simply done in the open air. I think that it is possible to break those arcs at 40,000 volts, but if it can be done neater and more safely in some kind of liquid that is the thing to look forward to.

Mr. Lighthipe.—The fact that a switch works very satisfactorily may lead to a great deal of danger. You may open a switch a dozen times without any great fireworks, but you will open it once too often when the line conditions are such that you will have more fireworks than you want to see. You may open and close a switch a dozen times without any disastrous effects, and the thirteenth time it may go all to pieces. You want to skip the thirteenth time.

Mr. A. H. Babcock.—I may offer a personal experience in the line spoken of. An arc was caused by a man backing into a wire carrying approximately 26,000 volts, and the holes in the roof showed very plainly where the arc had followed him as he rolled down the roof. The lowest hole—the one farthest away from the wires from where I took his body away—was approximately 8½ ft. from the line. That simply indicates that the arc followed him for that distance. It was a 26,000-volt arc, so I came to the conclusion that an arc can wave around for a very long distance on a comparatively low potential. I say low potential, as compared with 40,000 or 60,000 volts.

Mr. Masson.—The character of the load that Mr. Babcock mentions is extremely important. In opening these cables on a current of 1½ amperes at 10,000 volts, which to you people is extremely low—we have made an arc that reached up 6 ft. high from a switch. The character of the load solves the entire question of the length of the arc.

Mr. Theberath.—So far it seems that the discussion has brought out that the natural trend is to an oil switch. At the same time, another feature was brought out by Mr. Stark's question in regard to fuses which seems to be illustrated in the line of the Standard Co., and that is, the arc is opened through a fuse. In other words, a switch using a fuse as the opening point would protect the transformers. At the same time an oil switch would probably perform the same office, from the fact that an arc may exist for a certain length of time, and eventually be choked off by the oil so as to give the line sufficient time to discharge through the arc, and not puncture the insulation of the transformers. My opinion is that in the very near future all high potential switches will be oil switches, and it would be well for the manufacturers to look in that direction. Opening a switch in the air, as Mr. Lighthipe says, requires too much out-door room, and when we consider a substation taking current from a high potential line and figure on the cost of the building in order to install the lightning arresters, and the high potential switches, and so forth, we have a building about four times as large as that which would be necessary to accommodate the transformers. This can be eliminated by an oil switch. At the Colgate power station we have opened a short circuit on 60,000 volts, on a 3,000-HP. generator (on the low potential side, however) with an oil switch. The current at the time was away above the capacity of the generator. In another instance we opened the switch under a load of 500 amperes under oil at 2,400 volts. Instead of opening the switch suddenly, as you would with the switch in the air, we found the best way to open an oil switch is to open it very slowly, giving the oil a chance to dissipate the arc before getting too much distance between it; in other words, keeping the arc as short as possible instead of lengthening it out by a quick movement of the switch. The first time the switch was opened it was opened very quickly, and an examination of the switch indicated that the arc had been drawn out so quickly that the oil did not get a chance to get in between the contact points, and it burned the contact points slightly. When the switch was opened slowly the points were saved absolutely; no indications of any burns at all.

Mr. Poole.—It would seem, from some experiments that I have made on insulating oils, that it points to something other than oil for the insulation, or, rather, for the liquid that breaks the arc on extremely high voltages. I have noticed in testing transformer oil and switch oil in closed receptacles where it could be watched very closely that on separating the terminals to give 28,000 or 34,000 volts, it will break across and carbonize the oil very rapidly, so that you can see the black streaks in it. It would seem to be quite possible for those extremely high voltages to carbonize the oil sufficiently to establish an arc.

Mr. Martin.—After listening to the entire discussion, it seems to me that there is no necessity for throwing a high potential switch at either the substation or generating station unless you have a short circuit on the high tension side of your transformers. Even if this occurs, however, you will have nothing to protect, because the property is being destroyed anyhow. Thus the necessity for throwing the high-tension switches, to my mind, is very remote.

Mr. Theberath.—I disagree with Mr. Martin. We have cases where we must operate high potential switches. For instance, in the case of the day line we have two circuits which are put in as a safeguard for continuous operation. In case of trouble on one line, we have to be able to switch over on to the other line and transfer on the high potential side, whether there is a short circuit or not, regardless of the transformers. Furthermore, in connection with the long duplicate line there will be a time when the load will be so heavy that both lines will be required. Possibly some repairs may have to be made at some section of the line, and by introducing switches at, say, two or three points in the line, we could cut a small section of one of the lines out of service and make the repairs and still have the balance of the duplicate line in service. In that case we would have to do our switching on the high potential side.

Mr. Sterling.—I agree with Mr. Theberath. Mr. Martin suggests why not open the low-tension side; but that would interrupt our service and throw the motors out of use, so we have to have a high-tension switch that we can open. We protect our switches very thoroughly, we think, with asbestos, and we are waiting to see the fireworks when they do occur. We are relying a good deal on the small tubes, through which the arc has to be blown, which, I think, in great measure will dissipate the arc, thereby relieving the danger of the arc bounding to the iron roof, which, of course, is an element of danger in the Piedmont station. That calls to mind a very ingenious switch I saw in Montreal last winter, under which they used compressed air, and to my mind I think it is the coming switch. It not only breaks the arc suddenly, but cools off the contact part, thereby lessening the volatization of the metal which is feeding the arc. I think it is going to be an element in the coming successful switch.

HIGH-TENSION POLE LINE CONSTRUCTION OF THE STANDARD ELECTRIC CO., CALIFORNIA.*

By C. O. Poole.

The two limiting features in high-tension work are transformer design and line construction, and as it is quite possible to connect transformers in series to obtain extremely high voltages, it seems that the principal limiting feature is the line. I will give a brief description

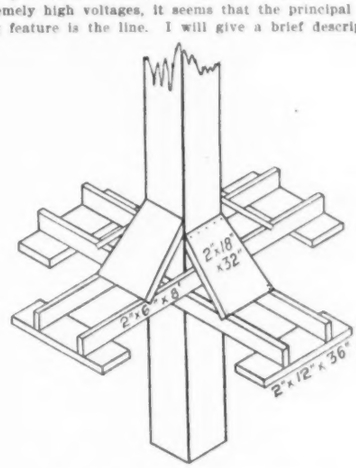
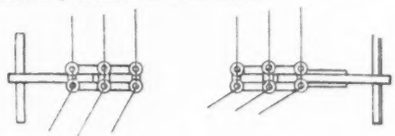


Fig. 1. Bottom Construction of Line Pole in Marshy Ground, Standard Electric Co.

of the pole line construction adopted by the Standard Electric Co. of California, confining myself principally to the mechanical construction, leaving the more complex electrical phenomena in other hands.



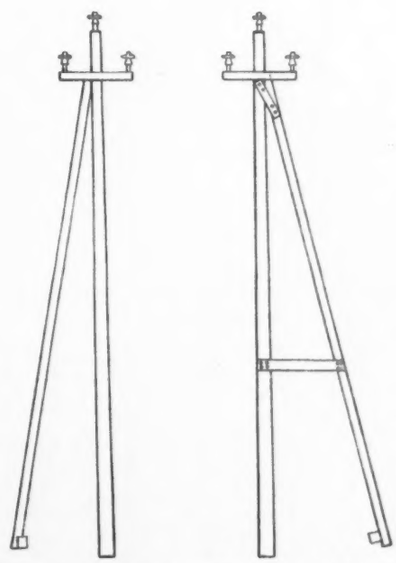


Fig. 2. Braced Pole for Flat Angles, Standard Electric Co.

Fig. 3. Braced Pole for Sharp Angles, Standard Electric Co.

The poles used are all of sawed redwood, and are taken from the hearts of young trees. Not more than four poles are taken from any one tree, there being no sap

*Extracted from a paper read at the fifth annual convention of the Pacific Coast Electric Transmission Association at San Jose, Cal., June 18 and 19. In further explanation of this paper, it may be noted that the transmission line described is a continuation of the 142-mile transmission line of the Bay Counties Power Co., which is described elsewhere in this issue. To summarize, the line of the Bay Counties Power Co. runs from the company's power house in the Sierra Nevada Mountains to Oakland, Cal., 142 miles, and at Oakland it connects with the line of the Standard Electric Co., which runs to San Jose, Cal., 42 miles. This paper describes the line construction of the 42-mile line from Oakland to San Jose.

No. 1 solid aluminum, and for cables ½-in. in diameter and under No. 4 aluminum is used. Our method of tying is somewhat different from any that I have seen in use, and we have found it to be very efficient. The line can be dead-ended at any pole, and the tie will hold the line without slipping. Fig. 7 shows the method of tying. In very hilly sections, where the line pitches up and down and the wire is thrown out of a true catenary curve, the table of deflections cannot be used. In such cases the foreman must use good judgment in allowing slack enough

Fig. 7. View of Insulator, Showing Manner of Tying Line Wire, Standard Electric Co.

—the tendency is to be a little bit too economical with his wire. In several cases we have had to make more slack by raising or lowering poles, as we have preferred this method to cutting and splicing the cable. We also make a practice of allowing a little extra slack on bad corners, so as to ease them during cold snaps.

The method of joining cable is quite an important feature, and the final selection of the joint used was determined only after extended experiments. Fig. 8 shows this joint, and it may be added it has proven satisfactory under most trying conditions. In testing the joint, the cable invariably broke just outside the joint before it would pull through. As will be seen from the cut, it is a right and left-hand screw joint, in which the two male parts are cupped out large at the thread ends. The

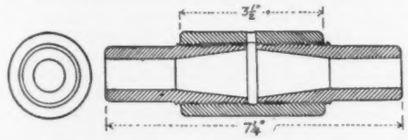


Fig. 8. Details of Cable Splice, Standard Electric Co.

method of joining the cable is as follows: The cable is cut off square with a hack-saw and the end passes through one of the male parts. About 1 in. of the ends of the cable strands are turned back upon themselves, and the knot thus formed is forced back into the socket, when a small tapered aluminum plug is driven into the center of the knot, filling the socket completely. The other part is treated in the same manner. The nut is then screwed on, which draws the cable ends together and makes a firm and solid joint. The resistance of the joint is less than the resistance of an equal length of the cable.

We now come to the most important of all the important features in high-tension transmission work—the insulator. Without tiring you with the details of the development of the insulator that the Standard Electric Co. is using, I will state briefly that at the time we adopted it there was nothing on the market that would anywhere near meet our requirements, hence it was not until after many months of cut and dry methods had passed before we obtained an insulator that would stand the exacting test to which it would be subjected. Fig. 9 shows the Standard insulator in section and perspective, and Fig. 7 shows it as erected. It is what is called a two-part insulator, the upper part being of porcelain and the lower part of glass.

There are several reasons why a combination insulator was decided upon. First, the dielectric strength of the glass is greater than an equal thickness of porcelain, while, on the other hand, moisture clings less readily to the porcelain. It was also found that a much cheaper insulator could be made in this way than making it either wholly of glass or of porcelain. As a matter of fact, the insulator as designed could not be made of glass in one piece. The two parts of the insulator are cemented together with a cement composed of sulphur and sharp sand in about equal parts. After being cemented together, every insulator is subjected to a test of 120,000 volts for a period of five minutes, and if any insulator shows a sign of weakness it is rejected. In testing the insulators the pins upon which the insulators are mounted are hollow and a wire leads up through the pin, terminating in a spiral spring at the top of the pin. This spring projects about an inch above the top of the pin. The pin is capped with a piece of sheet copper, about 1 in. in diameter, to present a good contact surface for the insulator to rest upon. The insulators are then placed on the pins, resting upon the contact, which is one terminal of the testing set. For the other contact there is used a piece of No. 14 soft copper wire that is fastened tightly around the tie groove of the insulator in the form of a noose and slip knot. Thirty insulators are placed on the testing rack at one time; when the pressure is gradually brought up to approximately 120,000 volts, the spark gap being set at 12½ ins. If an insulator gives away, it is replaced with another one and the pressure is applied again. This process is repeated until the nest of insulators stands the test for five minutes. It was found by experience that an insulator after standing the test for five minutes would seldom show signs of weakness when subjected to a longer exposure. This method of testing is very rapid, as two men will test 30 insulators in about 15 minutes, or an average rate of one-half minute for each insulator. The high-voltaging set consists of 12 transformers, each giving a pressure of 10,000 volts. The transformers are connected in groups of three on the low-tension side through insulating transformers, the high-pressure terminals being all connected in series. The pressure is regulated by a rheostat connected in series with the low-tension circuit.

The insulator pins used by the Standard Electric Co. are made from eucalyptus, or blue gum wood, specially seasoned and treated as follows: The timber is sawed into sticks 3 ins. square and placed in a vat of boiling water for 24 hours, when the sap becomes thoroughly boiled out, being displaced by the water. The timber is then racked up and air-dried for several months. The wood, after undergoing this treatment, is thoroughly seasoned and is tough and hard as hickory. The timber is then worked up into pins by a machine that completes the pin in one operation. The pins are then placed in a vat of boiled linseed oil, which is kept at a temperature of 210° F. for several hours. The oil penetrates the pins to a depth of about 1-16-in. and makes a very good moisture-proof finish. Its largest diameter is 2¾ ins., and it tapers to 2½ ins. at the upper shoulder. The diameter at the base of the thread is 1½ ins. and 1⅜ ins. at the top, the thread having a taper of ⅛-in. in 2¼ ins., the number of threads per inch being four. The shank of the pin is 2¼ × 4⅞ ins., and the length of the pin over all is 16⅞ ins.

Before the pin is driven into the arm, the shank is dipped into P. & B. paint, and some of the paint is put into the pinhole of the arm. A hardwood set is then placed on top of the pin, slipping down freely over the thread and resting upon the shoulder of the pin. An eight-pound sledge is then used to drive the pin home. This method of driving the pins into the arm has proven very satisfactory, for hardly ever has a pin been spoiled. Fig. 10 shows the construction of this pin-driving tool. On the base of the pin is used a porcelain sleeve 5 ins. long, which rests upon the crossarm and projects up be-

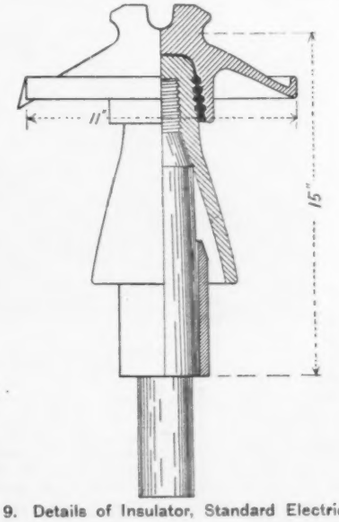


Fig. 9. Details of Insulator, Standard Electric Co.

neath the glass petticoat. The object of this porcelain sleeve is to protect the pin in the event of an arc tending to strike from the eve of the insulator to the base of the pin. It also protects the pin from weathering.

The crossarms are made from selected close-grained and kiln-dried Oregon pine. After boring, the arms are treated with asphaltum oil by placing them in an enclosed boiler under pressure and subjecting them to a temperature, while in the oil, of about 250° F. They are kept submerged in this oil for several hours until the wood is thoroughly permeated with the substance. Asphaltum oil has been found by experiment to be a very good insulator and it is also an excellent wood preservative. The distance between the pin holes of the crossarm is 42 ins., and the arm is placed on the pole in such a position that the wires form the points of an equilateral triangle having 42-in. sides. The arm is gained into the pole 1 in., and is held on with two ⅝-in. through bolts with large cast-iron washers. The pin holes are not bored through, for the reason that 1 in. of wood was left to add strength to the arm. The top of the pole is beveled off

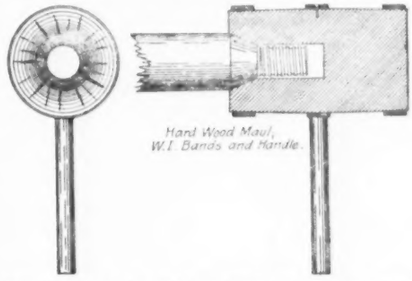


Fig. 10. Tool for Driving Insulator Pins, Standard Electric Co.

and an iron band ¼ × 1½ ins. is driven on to prevent the pole from splitting. The pin is then driven in as was done in the arm.

Having designed the pole top and secured samples of crossarms, pins and insulators, we may next proceed to determine the weakest point in the combination. In testing, we fitted up a crossarm, pin and insulator complete and then bolted the arm securely to an iron column. A sling was next fastened around the tie groove of the insulator, and, with a dynamometer in circuit with a pull chain, we split the crossarm into pieces with a pull of 1,200 lbs. Next a ½-in. carriage bolt was put through the arm at a point 3 ins. from the center of the pin and 2 ins. from the top of the arm, but when the pull was increased to 1,800 lbs., the arm split toward the pole. Another ½-in. bolt was put through the arm the same dis-

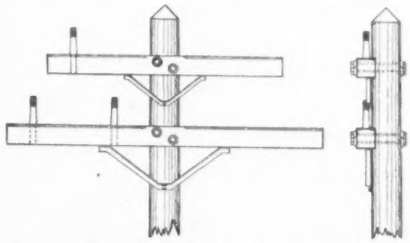


Fig. 11. Pole Top Construction for 10,000-volt Mountain Circuits, Standard Electric Co.

tance from the pin toward the pole, but the test applied broke the pin off squarely at the shoulder on top of the arm, at a tension of 2,200 lbs. These figures are not taken from a single test, but are the average of a series of tests. The cost of putting the four bolts in the arm, including the bolts, washers, boring holes and all labor in connection with it, did not exceed 10 cts. per arm, and it fully doubled its strength. All poles carry a 6-pin telephone arm placed 6½ ft. below the power arm.

The telephone line consists of a No. 8 B. & S. iron wire, which is transposed every four poles on a single transposition insulator. The power line is not transposed at all. Provisions are made for opening the power line at several points in case of trouble by means of switches in specially designed switch-houses.

Fig. 11 shows a pole top that has been recently adopted for the 10,000-volt mountain circuits. This method of construction permits of two separate circuits being carried on the same pole in the form of an equilateral triangle, and either circuit can be safely handled while the other is hot.

I am indebted to Mr. A. C. Bunker, the Stanley Electric Manufacturing Company's engineer, for the privilege of describing his design of pole tops.

A UNION ENGINEERING SOCIETY HOUSE.*

Our issue No. 33 mentioned the project of an engineers' building to be occupied jointly by the various engineering societies. At the present time when the house of the Mechanical Engineers has come to be inadequate in size, and when a project for an increase of dues to provide funds for sustaining a larger home is on foot, it

*Reprinted from an editorial in the "American Machinist."

whatever in the finished poles. The heights and sizes, together with the depths to which the poles are placed in the ground, are given in Table I.

In places where the ground is very soft and the tamping is not good the poles are set from 6 ins. to 1 ft. deeper than the depths given in the table. For crossing soft marsh land there is used what is termed a "bottom construction," which consists of a kind of maltese cross arrangement, made by spiking redwood pieces 2 ins. × 8 ins. × 8 ft. long on all four sides of the pole, as shown in Fig. 1. This construction is placed just below the ground, and a great weight of sod and earth is piled on top of it, reaching up the pole for a distance of about 3 ft. The plan has proven very satisfactory, having resisted the severe wind storms of last winter much better than some of the poles planted in firmer ground. On all angles greater than 2½° the poles are double constructed and strutted. On ordinary angles the strut is placed on the inside of the angle, and is fastened to a deadman buried in the ground to a depth of from 4 to 5 ft., as shown in Fig. 2. On extreme angles the strut is used as an anchor, placing the anchor on the outside of the angle instead of inside, as in the previous case. This construction is shown in Fig. 3. It has been found by experience in our work that on heavy angles, when the ground is wet and the wind is severe, that in the strut arrangement shown in Fig. 2 the pole has a tendency to ride the strut, and in some cases the pole has been pulled out of the ground. The arrangement outlined in Fig. 3, however, overcomes this difficulty, and I have yet to find one of them that has given way in the least. Wherever circumstances permit severe angles are taken on two double-constructed strutted poles, dividing the angle between the two poles.

For raising the poles we used a truck derrick; that is, a derrick mounted on the rear end of a low four-wheel

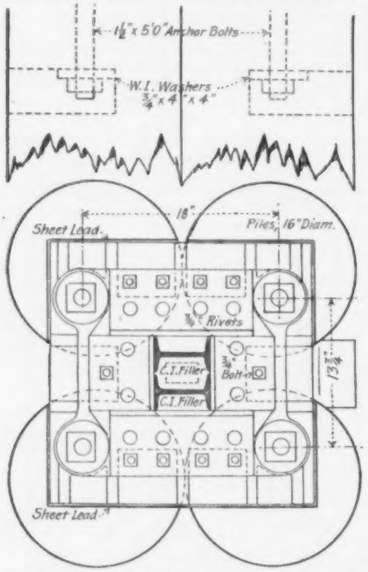


Fig. 5. Detail of Steel Tower Leg Support on Piles, Standard Electric Co.

truck, which is equipped with a windlass for controlling the position of the derrick. The truck is backed up to a position close to the pole and a sling is placed around it near the middle of the pole, to which the block is attached. The fall passes through a snatch-block fastened to the wheels of the truck, and the horses walk out along the line, raising the pole in position to drop into the hole. In places where the truck cannot be taken, the men pike in the small poles and use a gin pole for the larger ones.

On extremely bad ground, where there is "no bottom," we have resorted to the use of piles, in some cases using one pile, in other cases two piles, and in one place, where the line was forced out into the Bay of San Francisco, three piles were used for supporting each pole. The three different methods are shown in Fig. 4. This method of construction is rather expensive, but it offers the only solution for a difficult problem.

TABLE I.—Showing Height and Size of Poles Used by the Standard Electric Co.

Height.	Top, ins.	Butt, ins.	Depth in ground.
30 ft.	7 × 7	12 × 12	5 ft.
35 "	7 × 7	13½ × 13½	5 " 6 ins.
40 "	8 × 8	13½ × 13½	6 "
45 "	9 × 9	15 × 15	6 " 6 "
50 "	10 × 10	16 × 16	7 "
60 "	11 × 11	17 × 17	8 "

Where the poles are supported over water, platforms 4 ft. square are built around the bases of the poles at the top of the piles to facilitate line constructions and repairs. These platforms are reached by a light board 10 ft. long, which spans the distance between the platform and the railroad trestle, inside of which the pole line extends. Where the line crosses salt marsh lands which are flooded by high tides, an elevated walk has been built for the patrolmen; 4 × 6-in. posts are driven into the ground at a distance of 16 ft. apart with a heavy maul. This distance is spanned with a foot-plank having 2 × 6-in. pieces spiked to its edges. The plank is sprung up in the center for a distance of about 2½ ins., thus making a truss of each plank. This construction has proven very satisfactory, and is quite inexpensive to build.

There are several places where the line crosses navigable streams. As the government requires a clearance of not less than 115 ft. above high water, we had to look to something other than poles to make the crossings. The longest span encountered was 618 ft., in which the sag in the line is 19 ft. Allowing 12 ft. for a second line to be run later, makes the total height 146 ft. The method adopted for crossing these streams is to use towers. These towers are 150 ft. high, and are designed to carry two circuits of three wires each, one circuit being placed above the other. The tower tops are made of seasoned Oregon pine; the cable strains are taken on four and six insulators. The crossarms (or, rather, the longitudinal arms in this case) are shaped to fit the curve of the cables so as to divide the strain on the insulators. Some of the towers were compelled to take a horizontal angle, and in order to equalize the strain on the insulators and pins the arms were curved both vertically and horizontally.

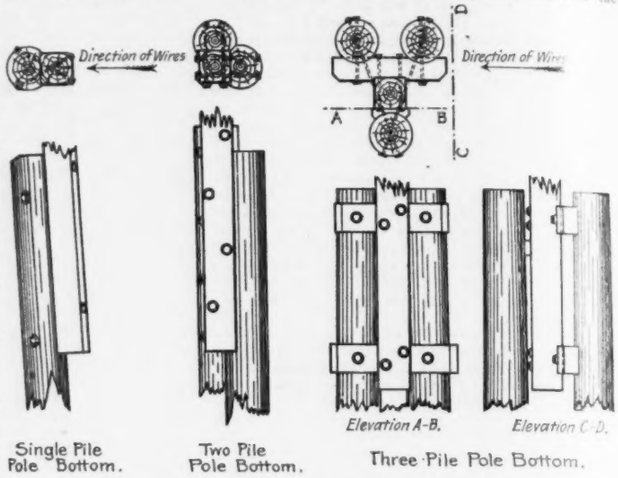


FIG. 4. PILE BASE CONSTRUCTION FOR POLES SET IN WATER, Standard Electric Co.

As the ground in the location of the towers is very soft, it was found necessary to use piles for foundations. The base of the tower is in the form of a quadrangle 25 ft. square. Under each crossing are driven four redwood piles 16 ins. diameter at their butts. The four piles are driven as a solid cluster, securely bound together above ground with steel cables. The tops of the piles are sawed off on a slant to suit the batter of the tower members and capped with a cast-iron shoe bedded on a piece of sheet lead. A galvanized iron bolt 2 ins. in diameter passes through the cap and down into each pile for a distance of about 4 ft., the nut and washer for the lower end being mortised into the pile. The detail of this work is shown in Fig. 5. As the cables leave the towers they drop to wooden take-offs, located about 550 ft. distant from the towers. The take-offs consist of two 40-ft. poles strutted two ways, with mudsills for supporting the struts and tying the frame together.

Having described the pole line from a ground man's point of view, let us now put on our spurs and see what is going on at the top of the pole, where the line is radically different from the pole line of a few years ago. The line was designed to carry 60,000 volts with safety, and as a single circuit is to carry 10,000 HP. a distance of 150 miles at less than 10% drop, the conductors must necessarily be large. This adds to the problem a mechanical difficulty not heretofore encountered.

The main line consists of three aluminum cables, each ⅞-in. in outside diameter and made up of 37 strands, having a total cross section of 471,034 circular mils. The weight per mile is 2,404 lbs., and the resistance per mile is 0.205 ohms. This cable is all specially drawn and laid right and left hand. Its tensile strength is 28,000 lbs. per sq. in. In stringing the cable the deflections given were calculated for a maximum strain of 4,000 lbs. per sq. in., giving a factor of safety of 7 at 20° F. The very high coefficient of expansion of aluminum requires careful consideration in stringing aluminum wire. The first impression one is likely to have of an aluminum line when seen on a hot day is that it is about time for the lineman to come along and cut out some slack, but if one sees the same line on a cold, frosty morning he will feel very much as though some lineman should cut in slack, instead of taking it out. A 132-ft. span, having a deflection of 33 ins. at 100° F., will have a sag of but 13 ins. on a cold morning. Fig. 6 is a diagram of deflections for different spans and temperatures, based on a mechanical strain of 4,000 lbs. per sq. in. at 20° F. In this will be noticed the fact that there are two sets of temperature figures. The upper set I have called "mountain temperatures" and the lower set "valley temperatures." In the diagram the figures are simply shifted 10° to the left, which gives about 8% less sag in the valleys, where the temperatures are less likely to reach the 20° mark.

It might be of some interest to know how the large cables are handled. The cable is shipped from the factory on hardwood reels, each reel containing a cable one mile in length. Wherever the ground would permit the reel would be mounted on a stand and the reel-stand placed on the rear end of a low four-wheeled truck. The team would then be driven out along the pole line, paying out the cable as the truck went along. A brake is used on the reel to steady the paying-out process. After the cable is laid out on the ground, the linemen, with hand ropes, hand it up on to the crossarm. On one section of the line a special two-wheel cart was used for paying out the cable, and it proved to be quite satisfactory. The cart was so designed that the wheels could be taken off easily and the axle slipped through the center of the reel, using the axle for a reel-shaft.

In the rough mountain districts the men were forced to use the time-worn method of pulling out over the arms, sometimes using a team of horses for pulling the cable out, and at other times resorting to their good brawn in places where a goat could hardly find a foothold. Our plan of work is to lay out several miles of cable over the crossarms and then place the cable on the insulators. Each gang-foreman is provided with a handy, accurate thermometer. Each lineman on the poles has a sighting target, which hangs from a cord that is knotted every 2 ins. These knots fit into a small brass hook, which is hung on the wire close to the insulator. The blocks and falls are then put on, one wire at a time, and from six to eight spans are pulled up at once. The foreman, after consulting his thermometer, gives the number

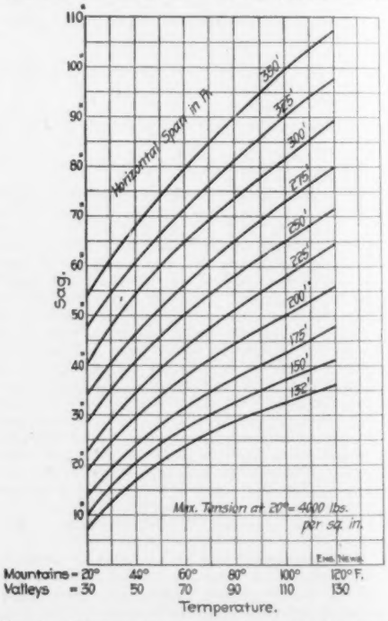


Fig. 6. Diagram Showing Deflections of Aluminum Wire for Different Spans and Temperatures, Standard Electric Co.

of the knot to be placed on the hook, and the lineman on the crossarm sights from his target to his comrade's target on the next pole. When the slack of the line reaches the line of vision he sings out and then ties in. This is repeated from pole to pole until the six spans are completed, when the blocks are moved ahead and made ready for another stretch.

The size of the wire used for tying the large cable is

seems fitting that attention should be directed to the advantages to be derived from a union building.

No one who is familiar with the facts can fail to be impressed with the great waste of the present plan. Except during the fall meeting, the house of the Mechanical Engineers is almost a solitude. A visitor will find perhaps a few (very few) readers in the library, and a few out-of-town members make use of the sleeping rooms, and these, together with the office force of the society, comprise ordinarily the whole number of occupants. During the three or four days of the fall meeting the house is, on the other hand, thronged, and is, in fact, at that time altogether too small for its purpose. It was, of course, occupied during a few evenings of last winter by the now-given-up junior meetings, and a small revenue is derived from the rental of the audience hall and parlor for other meetings.

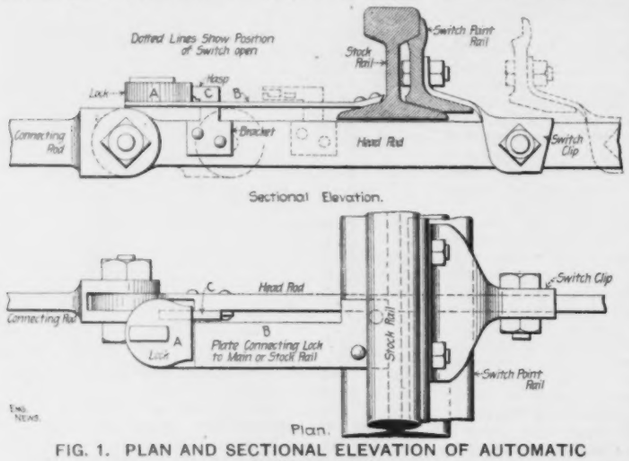


FIG. 1. PLAN AND SECTIONAL ELEVATION OF AUTOMATIC SWITCH LOCK.

Walter E. Emery, West Chicago, Ill., Inventor.

Substantially the same state of things exists in connection with the house of the Civil Engineers, in 57th St., although the system of semi-monthly meetings which that society adopts brings its house into more frequent use by the membership, and it is, we believe, somewhat more largely used in other ways than is the house of the Mechanical Engineers. The Mining Engineers maintain, through settled policy, a secretary's office only, and the Electrical Engineers do the same, though probably more from the necessity of economy than deliberate policy. The Society of Naval Architects and Marine Engineers occupies the house of the Mechanical Engineers as a tenant.

No one, and least of all an engineer, can regard such a state of things as satisfactory. The efficiency of the mechanism is altogether too low, and yet, notwithstanding this, the Mechanical Engineers are now asked to deliberately tax themselves to perpetuate the same conditions on a larger scale; for, when the new house is finished and occupied, the conditions of its use will in no wise differ from those of the present one.

The eminently proper and, indeed, the only sensible solution of the problem lies in a union society house with one large audience hall to be used by all, one union library (or perhaps we should say union of books, for the ownership should be kept separate), separate rooms for the officers and clerks of the different societies and a suitable number of sleeping rooms.

This plan does not contemplate any union of the societies, which is impracticable and probably undesirable. It simply contemplates an engineering building, adequate to the needs of all and worthy of the commanding position which the engineering profession has reached, which is to be occupied by the separate societies in the manner described. It is obvious that the needs of the societies would be far better met by such a building and at much less cost to each than by the present plan.

Not the least of the advantages of the plan lies in the possibility of a union library. It is well known that a very insignificant amount of money is spent on the Mechanical Engineers' library, because the society has but little to spend. Except as regards serials and periodicals it is not kept up, and most of these additions are, we believe, obtained through exchange for the Transactions.

At one of the meetings some years ago complaint was made of the inadequate expenditure for the library, and in explanation it was stated that the council considered it better policy to utilize the available funds of the society in cancelling the second mortgage bonds on its house rather than in buying books, and the hope was held out that when these bonds were paid off the library would receive adequate attention. The bonds are now cancelled, but the enlarged membership calls for increased accommodations, and should the society buy or build another house of its own, the result can hardly be other than the starvation of the library for another generation.

All this would be changed with the construction of a union building. A superior engineering library could soon be acquired which, under proper plans for the mail circulation of books, could be made available to all the membership. It is not improbable that the economies of the plan might be so great as to enable the societies to engage in experimental research after the methods of some of the English societies.

The mining engineers, for reasons of their own, which they consider sufficient, do not wish a headquarters other than a secretary's office and their co-operation is not to be expected. The other societies, however, have nothing in their policies which are inimical to it. It stirs one's blood to think of the building which they could maintain and of the influence which it would exert on the engineering profession and on the estimation of the profession by the general public.

The most serious obstacles to the carrying out of the plan is, of course, the house of the Civil Engineers, which is almost new and which was built especially to suit their needs. In view of the possibility of a union building we have always looked upon the construction of that building as almost a crime, though who is responsible for it we do not know. In view of its existence we believe that the best present solution of the problem which confronts the Mechanical Engineers would be for a time to use the Civil Engineers' building as a tenant. The plan of joint occupancy could thus be tested, and, if found to possess the advantages which we believe would attach to it, that building could at a latter date be enlarged and the other societies be taken in with such change in the basis of ownership as would be feasible.

The plan may not be feasible, but it ought to be feasible. We do not know what obstacles there may be to carrying it out, but whatever they may be we do not believe they are due to the membership at large of any of the societies. We have no doubt whatever that the membership bodies would cordially approve the plan were its advantages once pointed out to them. Official jealousies on the part of the management of one or more of the societies there may be (we do not mean to imply that there are), but it is the membership which is chiefly interested, which supplies the money and pays the bills and the membership should take the matter in hand.

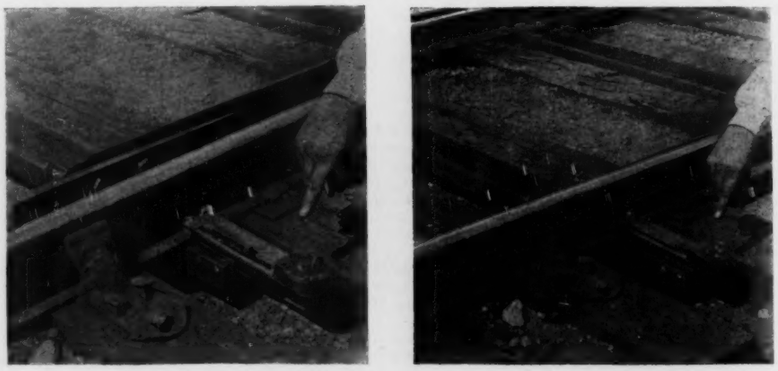
The plan of a separate building for each society has nothing in its favor and everything in its disfavor. It is, in short, a folly which the members of the societies, as sensible men, should not countenance, much less uphold. We are opposed to the building of another house by the Mechanical Engineers until co-operation has been found to be impracticable. If the folly must be committed it should be because other societies refuse to co-operate and not because the Mechanical Engineers do not possess common sense.

The plan at present contemplated virtually asks the members of the American Society of Mechanical Engineers, scattered throughout the country, most of whom seldom, if ever, make any use of the building or have any opportunity of doing so, to go down into their pockets for ten additional dollars per annum, and for what? Why for the erection and maintenance of a building, not only not used directly by them, but to be used by no one except for about four days during the year, unless the society is fortunate enough to obtain tenants, and it is certain not to obtain enough of these to amount to very much. Official notice of the presentation of a resolution increasing the dues of members from $15 to $25 and of associaties and juniors from $10 to $15 was given at the Milwaukee meeting, and we understand is to be voted upon at the fall meeting. We hope every member will be given the opportunity to vote upon it by mail or otherwise. There are a good many worthy members of the society to whom an increase of $10 per year in dues is of some importance, and we think most of them will at least want better evidence than is now available that there is some real necessity for the increase.

AUTOMATIC LOCK FOR SWITCH POINTS.

The device illustrated in the accompanying cuts has been invented as a safety attachment for facing point switches, its object being to lock the switch rail firmly to the stock rail when the switch is set for the main track. The lock A is attached to a bracket B, bolted to the outer side of the flange of the stock rail. On the head rod or switch rod is bolted the hasp C, and when the switch is thrown for the main track this hasp enters the lock and is automatically clutched and held, so that the switch cannot be moved. The hasp may be attached directly to the switch rail in operation if desired, so that when the switch is finally locked the whole device fits close to the ties, where it is not liable to be injured. The switch is set and locked at one operation. Fig. 2 shows one of the locks applied to a switch on the Chicago & Northwestern Ry., with the switch set in both of its positions.

To release the switch, an ordinary switch key is inserted in the lock and turned in the usual way, but when the switch is again set for the main track, it is again automatically locked in that position. To render the lock inoperative, as for switching cars, when it would be very inconvenient to have to unlock the switch for every movement, the key is only turned half-way round and left in the lock. The switch can then be thrown without locking, but when the work is done, the key must be turned before it can be withdrawn, and in turning, it again puts the lock set for the main track in its former position. An ordinary switch key is used, so that no special keys have to be issued for the men, and one important feature of the device is that it enables the lock on the switchstand to be dispensed with, the locking being effected at the rail and not at the switchstand connections. Consequently, should the switchstand or the connections be broken or out of order, this would not affect the safety of the switch. The lock may, however, be applied to the switchstand, should this arrangement be preferred, or it may be operated in connection with the switch signals. This lock is also applicable to freight car and other doors.



Switch Open. Switch Closed.

FIG. 2. PERSPECTIVE VIEWS OF AUTOMATIC SWITCH LOCK.

The automatic switch lock above described is the invention of Mr. Walter E. Emery, Roadmaster of the Chicago & Northwestern Ry., at West Chicago, Ill., to whom we are indebted for drawings and other information.